The Journal of Parasitology

Volume XII DECEMBER, 1925 Number 2

SPECIATION AND SPECIFICITY IN THE NEMATODE GENUS STRONGYLOIDES *

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Systematic differentiation between species in the genus Strongyloides is at present in a somewhat unsatisfactory condition. Among many genera of nematodes, some of the most important and reliable characters for specific diagnosis are provided by the sex organs and certain associated structures in the males. The absence of males in the parasitic generation of Strongyloides deprives us of many of the most valuable criteria upon which specific diagnoses may be based while the females offer few characters for this purpose. The parasitic Strongyloides are usually of microscopic size, ranging in length from less than 2 mm. in the case of *S. ratti* n.sp.† to nearly 9 mm. in the case of *S. westeri*. The cuticula is finely striated transversely but otherwise devoid of ornamentations such as papillae, etc. The mouth cavity is exceedingly shallow and is not provided with cuticular thickenings in the form of ridges or teeth. So small are the proportions of the organism that there is even a difference of opinion in the matter of the number of papillae surrounding the oral aperture. Wedl (1856) and Gedoelst (1911) state that there are four circum-oral papillae in *S. papillosus;* Ransom (1911) on the other hand considers that there are probably six. (It may be mentioned here in passing that in many specimens of various species of Strongyloides that I have examined there are six circum-oral papillae, two pairs submedian and one pair lateral; in some specimens, however, it is difficult to mount the organism in such a way that an absolute determination of the number may be made.) This fact alone will serve to indicate the difficulties encountered. Indeed the situation at present is so confused that many workers of established reputation are unable to recognize differences in forms of Strongyloides which one might with justification

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† For specific diagnosis see p. 73.

from other standpoints consider to occupy distinct specific rank. Thus Looss (1911:215) stated: "Besides being found in man, species of Strongyloides are very frequent in animals (mammals, birds and reptiles); so far as my personal observation goes, they so greatly resemble *Strongyloides stercoralis* that it is difficult to say whether they are the same species or not. The free-living generations, on the contrary, so far as I am acquainted with them, show slight but distinct differences from one another, which makes it probable that different species exist." Looss remarked further (p. 264) that in various African monkeys (species not designated) a species of Strongyloides was found which was indistinguishable from *S. stercoralis* and which Looss was inclined to consider as this species. No comment was made by Looss on the action of von Linstow (1905) in establishing the species *S. fülleborni* for the reception of the parasite from certain African primates. Baylis (1923) notes the occurrence of a species of Strongyloides indistinguishable from *S. stercoralis* in a snake. This same writer further records from Looss' collection a form of *Strongyloides* from the esophagus of a snake, *Eryx jaculus*, and one, again indistinguishable from *S. stercoralis*, in a bird of the family Otididae. These discoveries led Baylis to suggest that *S. stercoralis* "has not yet become confined like most parasitic nematodes to a limited range of hosts by special adaptation for a parasitic existence."

Homogeneity of structure which is one of the most characteristic features of the members of the genus Strongyloides may be an expression of the primitiveness or the archaic nature of the parasite. This view perhaps receives support when one considers that most nematode parasites have become so specialized and so delicately adapted to their parasitic mode of life as to restrict themselves to a well defined location in the host's body. In contradistinction to this, the parasitic stage of Strongyloides, although occuring mainly in the duodenum and jejunum, has also been found throughout the alimentary tract from esophagus to rectum (Blacklock and Adler, 1922) as well as in the trachea (Fülleborn, 1914). The difficulty of securing any well defined characters upon which specific differentiations may be based has led to a tendency on the part of many investigators to erect a new species for a parasite because of its occurrence in a new host, while others take the opposite position by stating that the parasite is morphologically indistinguishable from *S. stercoralis* and leave the onus of its separation from this species to later investigators. Unfortunately the description of many new forms is but a mere enumeration of the principal dimensions of the body and is seldom accompanied by adequate diagrams which might allow for comparisons being made without recourse to the actual type material. There has likewise been a disposition in describing new species, to consider only the parasitic generation and to neglect other phases in the

life-cycle. In some cases this has been due to the availability of preserved material only, as well as to the fact that the free-living phases in many species are remarkably similar in their appearance. Yet it is certainly possible to distinguish at least one species, namely, *S. fülleborni*, on the bases of the morphology of the bisexual generation.

Descriptions of species of Strongyloides are naturally constructed around the type species, *S. stercoralis*. This species is small and it is not easy to select characters for comparison with other species. Among the characters stressed by previous authors for establishing specific differences in the parasitic individuals, the following may be noted which apparently do not have the value attributed to them.

1. Total size of the worm and the relative size of the various organs such as esophagus (see Hung and Höppli, 1923).

2. The presence or absence of striations in the cuticula (Hung and Höppli for *S. simiae*).

3. The shape of the tail and the distance between the anus and tip of tail. These characters have received consideration in this study and each will be discussed separately and evaluated in terms of its validity for purposes of speciation.

SIZE AND BODY PROPORTIONS

The size of any organism is naturally subject to considerable variation primarily in terms of its age in so far as this is an expression of growth prior to the attainment of the adult size. The range of variation among individuals in an adult population may be considerable but it is never as great as the "pre-maturity" range. Consequently in establishing the normal range in size, it is necessary to take only mature individuals into account and to introduce a fairly large series of organisms. Unfortunately it is not possible to construct curves of the normal size range with the data available for most species of Strongyloides, since it is evident that the dimensions given have been taken from but a few and sometimes only a single specimen. For many of the species already established it is apparent that the size ranges overlap considerably. Thus for example: *S. papillosus*, length 2.8 to 6 mm.; *S. suis*, length 3.75 to 4.05 mm.; *S. ovocinctus*, length 4.5 to 5 mm. These species could certainly not be differentiated on the basis of size only. Hung and Höppli (1923) have called attention to the lack of any size distinction between many of the species of Strongyloides; these authors were, however, of the opinion that the relation between the length of the esophagus and the total body length is a distinctive character and, as such, may be of value for specific differentiation, at any rate between certain species. They have used this character as a major distinction between *S. fülleborni* and *S. simiae*. For *S. simiae* they found the esophagus

ranged between 18 and 25% of the body length in ten specimens. However, they had no material of other species upon which they could determine the range of variation in this ratio but had to base their distinctions on the data as recorded in the published descriptions of other species which, as I have already pointed out, are often derived from a single organism. On carefully measuring individuals of various species by the camera lucida drawing method, I find that the range of variation in the ratio of esophagus to total length as well as in other body proportions is so great that little reliance can be placed on these factors. For instance, in my material of *S. papillosus* obtained from a number of hosts, the ratio of esophagus to total length was 17.50 to 25.05%; in *S. fülleborni* the range was from 23.35 to 28.33%, and in *S. ratti* n.sp. the range was from 22.2 to 33.0%.

CHARACTER OF THE CUTICULA

Hung and Höppli (1923) have pointed out that both *S. fülleborni* and *S. cebus* are described as possessing a smooth cuticula and they interpret this to mean that the cuticula is not striated. In *S. simiae* they found the cuticula was finely-striated transversely. On examining my material of *S. fülleborni* I find that the cuticula is striated but so finely that in some parts of certain specimens the striations are very difficult to resolve even under the oil-immersion objective. It is therefore not surprising that if the organism was not especially examined for this character it would be described as "smooth" or more concisely even as "unstriated." In all my material of seven species of Strongyloides cuticular striations could be made out and so I believe that the distinction of *S. simiae* from *S. fülleborni* on this character does not hold good.

SHAPE OF THE TAIL

My first impression on comparing this character in various species was that it could be used as a specific character particularly in the case of *S. papillosus* and *S. ratti*. It is difficult, however, to get a real conception of the range of variation in this feature unless outlines which may be compared are drawn. In doing this a precaution that must be taken is to be sure that the shape of the tail has not been altered by pressure of the cover-glass on the specimen. The variations in the shape of the tail and the distance between the anus and posterior extremity of the body are brought out in Plate VIII. From this series of drawings it may be seen that it is not possible to use this character for specific purposes.

After considering critically the various characters that have been used in the differentiation of species in this genus it became evident that no one taken alone is of absolute validity for this purpose and it therefore became necessary to consider the possibility of other characters

being used. Usually in descriptions of various species, the size of the eggs and the number present in the uteri at any time is especially mentioned. The range of variation in these characters is relatively so great and readily observed even in a summary examination that little if any reliance can be placed on them. In the course of an extensive investigation on the life cycle of Strongyloides (now in press) the writer has had reason to pay special attention to the character of the gonads and the manner of oviposition in the parasitic females and to the morphology of other stages in the life cycle. The results of these studies has provided certain characters which I believe to be of sufficient constancy to allow for specific differentiation between certain species. These characters and others which have proved of diagnostic value will be considered under the following captions.

THE STAGE OF THE PARASITE FOUND IN FRESH FECES

The phase in which the offspring of the parasitic generation appear in the feces was found to be a constant character which differed to some extent in certain species. Thus, normally in *S. stercoralis* the larvae have already hatched from the eggs when they are extruded from the host's body. On the other hand, in *S. fülleborni, S. cebus* and *S. papillosus,* etc., the larvae are still contained within the egg when they appear in fresh feces. In *S. ratti* an intermediate condition is found; feces examined immediately after evacuation contain both larvae and eggs enclosing fully developed larvae, in about equal proportions. On this basis it is possible to differentiate between *S. stercoralis, S. ratti* and the following species: *S. fülleborni, S. cebus, S. papillosus,* and *S. westeri.*

THE RHABDITIFORM AND FILARIFORM LARVAE

The size of the rhabditiform larvae is subject to great variation since they are in a continual state of growth prior to metamorphosis. The filariform larvae are also subject to considerable size variation in all the species examined. Thus in *S. papillosus* the size variation in 20 larvae picked at random from various cultures at different times was from 0.576 mm. to 0.864 mm. In *S. ratti* 25 specimens ranged from 0.560 mm. to 0.736 mm. In *S. fülleborni* the range was from 0.532 mm. to 0.618 mm. and in *S. cebus* from 0.520 mm. to 0.640 mm. As in other stages in the free-living phases of the genus, growth occurs in the filariform stage. It appears that size in these stages can be correlated with the age and temperature to which the organisms were subjected during development and probably as well as with the available food supply. The shape of the notch in the tail was also examined in large numbers of filariform larvae to determine whether it offered a basis for the differentiation of species but with negative results. It was found that the notch in the tail was formed by the rupture of the tail at the time that

the filariform larvae emerged from the old cuticula in which the metamorphosis from the rhabditiform stage had taken place. The shape of this notch is determined by the resultant of two opposing forces: that of the larva in extracting itself from the old sheath and the opposing force of the sheath itself. As both of these forces may easily vary within certain limits, so the shape of the notch that is formed may also vary slightly.

MORPHOLOGY OF THE BISEXUAL GENERATION

In the male there are two cuticular papillae, one pre-anal and the other post-anal. The papillae are small and inconspicuous, but they were present in all species that were examined. In the female no cuticular papillae were found. The most conspicuous difference that can be observed in females of different species is associated with the vulva. In *S. fülleborni,* as von Linstow (1905) has depicted, the lips of the vulva are very conspicuous. Also the width of the body anterior to the vulva is considerably wider than posterior to this spot. This was a constant feature in all the organisms examined from fecal cultures coming from *Anthropopithecus troglodytes,* 3 specimens of *Pithecus rhesus* and one specimen of *Macacus* sp. In *S. cebus* Darling, the vulva is not so prominent as in *S. fülleborni* while Dr. Höppli has informed the writer that this feature also is not present in the bisexual generation females of *S. simiae.* It is I believe the most reliable if not the only character whereby *S. fülleborni* may be differentiated from the other species recorded from primates.

The size of the individuals of the free-living generation also varies considerably. In this instance size may be definitely correlated with the temperature at which development occurred. In some experiments designed to determine the extremes of temperature at which development of the bisexual generation may occur, I found that at low temperatures some of the larvae are able to develop to maturity but that they are decidedly dwarfed. Thus at an incubation temperature of 11 to 13 ° C. after four days of development, mature males measured from 0.710 to 0.860 mm. in length, while males developed at 26 ° C. measured 0.870 to 1.075 mm. Females at the same low temperature measured 0.73 to 0.91 mm., while others developing at 26 ° C. measured 0.95 mm. to 1.38 mm.

Lutz (1885) states that rhabditiform females of the form of Strongyloides in pigs in Brazil were nearly twice the size of those described by Perroncito for *S. stercoralis.* Fülleborn (1914) described "dwarf" forms of the bisexual generation of *S. stercoralis* developing in cultures from dogs and thought that this phenomenon might be due to the intensity of the infection. It seems probable to me that the unusual

size in both of the above mentioned cases may be correlated with the temperature of development as well as to the conditions of nutrition in the cultures.

DISPOSITION OF THE OVARIES IN PARASITIC FEMALES

A character which often affords a good diagnostic feature for certain species of Strongyloides is to be found in the disposition or the course of the ovaries in the parasitic generation. This character was first discovered when, subsequent to failing in attempts to procure reciprocal infections of rabbits and rats with their respective parasites, a careful search was made for morphological differences that might support the idea that the two forms were distinct species rather than biological varieties. On examining the ovaries of *S. papillosus* of rabbits it was found that both the anterior and posterior ovaries were twisted whereas in the rat form, referred to as *S. ratti*, the ovaries were directly recurrent or, perhaps more aptly expressed, form "hair-pin bends." In the twisted ovaries both limbs of the organ act as a single unit; in the anterior ovary a spiral is formed with the intestine acting as the axis of the spiral. In the posterior ovary, however, the intestine is not involved and lies clear of the ovary, which runs a sinuous course. In one of the 32 specimens of *S. papillosus* that were examined for this character, the posterior ovary was found to be straight and not sinuous. This may have been caused by rapid diffusion of liquid into the body cavity which would tend to straighten out the ovary in the course of preparation for permanent mounting. Straightening of the anterior ovary, however, is not likely to occur since, the spiral is held permanently by the intestine around which it is wound. In *S. ratti* five specimens out of over 40 examined had sinuous ovaries while the remainder had straight "hair-pin bend" ovaries. It is evident therefore that this character in *S. ratti* is relative rather than absolute. The course of the ovary may be seen in living material but in fixed material it is usually necessary to stain the worms with carmine or hematoxylin to bring it out more clearly. Material of other species of the genus have also been examined with respect to the disposition of the ovaries with the following results: *

In about 50 specimens of *S. ovocinctus* and in 16 specimens of *S. fülleborni*, both anterior and posterior ovaries are sinuous or twisted. In 4 specimens of *S. suis* mounted many years ago by Dr. B. H. Ransom, 3 specimens had ovaries which were definitely twisted while the fourth specimen showed twisting only in the anterior ovary, the posterior ovary being of the "hair-pin bend" type. In 46 mounted specimens of *S. stercoralis* from experimentally infected dogs, the anterior and poste-

* The course of the ovary showing its sinuous or twisted character is depicted in Plate IX, B. The "hair-pin bend" type is represented in figure A. It is also shown in Looss' diagram of *S. stercoralis*. (Looss 1911, pl. XIII, fig. 151.)

rior ovaries were all of the "hair-pin bend" type.* In only two of the four specimens of *S. nasua* were the ovaries sufficiently well preserved to permit of their being examined for this character; in these specimens both the anterior and posterior ovaries were of the "hair-pin bend" type. In 3 specimens of a form collected from *Hydrochoerus hydrochoera* by Dr. E. A. Chapin both anterior and posterior ovaries were all of the "hair-pin bend" type.

The genus Strongyloides is of cosmopolitan distribution. Besides occurring in many mammals, representatives of the genus have been recorded from amphibians, reptiles and birds but since no descriptions, other than that they are indistinguishable from *S. stercoralis,* accompany these latter records, it is difficult to assign them to their proper systematic positions. It would seem advisable to relegate these organisms to the category of *species inquirendae* until more is known of their life-history. It seems extremely doubtful to me whether Teissier (1896) who recorded the experimental infection of frogs with larvae of *S. stercoralis* actually obtained the results that he claims. It appears probable that he mis-identified the "giant Anguillula" that he found in the intestine and in extra-intestinal haemorrhages after feeding a frog with a few larvae of *S. stercoralis.* At any rate my attempts to repeat this experiment failed. *"Anguillula stercoralis"* has also been recorded, however, from frogs in three localities in Italy by Alfieri (1908).

In summing up the consideration of speciation in this genus, I may repeat that the incompleteness of certain records at present permit us to recognize representatives of the genus in mammals only. The parasite in no instance has undergone any fundamental morphological differentiation which can be correlated with physiological adaptation toward special environmental conditions in a particular host species. The most outstanding differences that are recognized in our present conception of specific distinction in the parasitic generation is that of size, but the relation that obtains between a parasite and its hosts must not be disregarded in the evaluation of this character. There appears to be no single character by means of which a specimen may be relegated to its specific position; on the other hand it is, I think, possible to make a determination in a considerable number of individuals if a number of characters representing the different stages in the life-history of the form be jointly considered. In the following section, it is proposed to review the various described species as listed by Stiles and Hassall (1920) in the Index Catalogue: Roundworms, and to consider the validity of some of these species in the light of certain information that has accrued from morphological studies and from infection experiments carried out in the course of my investigations on the life-cycle of the parasite.

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* *S. westeri.* Both the anterior and posterior ovaries in this species are according to Ihle's description (1918: 373) also of the spirally twisted type.

The species listed by Stiles and Hassall (1920) are from mammals only. They are:

bovis Vryburg, 1907 (from cattle, Sumatra). According to Ransom (1911) this organism does not belong to the genus Strongyloides; he refers it to *Cooperia punctata.*
cebus Darling, 1911 (from *Cebus hypoleucus,* Panama).
fülleborni von Linstow, 1905 (from *Anthropopithecus troglodytes* and *Cynocephalus babuin*).
longus bovis de Gaspari, 1912 (from *Bos taurus,* Torino).
nasua Darling, 1911 (from *Nasua narica panamensis,* Panama).
ovocinctus Ransom, 1911 (from *Antilocapra americanus,* U.S.A.).
papillosus (Wedl, 1856) Ransom, 1911 (from sheep, goats, rabbits, rats, etc.).
sp. Parona, 1894 (from *Mus decumanus;* Hall, 1916, quotes Grassi and Segré, 1887).
stercoralis Bavay, 1876 (from Homo; widely distributed).
suis (Lutz, -?- not verified) von Linstow, 1905 (Syn. *S. longus,* Grassi, 1885).
viviparus (Probstmayer, 1865) von Linstow, 1905 (from *Equus caballus,* Europe). This species transferred by Ransom, 1907, to *Probstmayria.*
westeri Ihle, 1917 (from *Equus caballus,* Holland).

Since the above list was published the following three species were announced:

canis Brumpt, 1922 (from *Canis familiaris,* Japan and China).
vituli Brumpt, 1921 (from *Bos taurus,* France),
simiae Hung and Höppli, 1923 (from *Macaca* sp.).

To this list, the writer proposes to add two further species:

chapini n.sp. (from *Hydrochoerus hydrochoera* in National Zool. Garden, Washington, D.C.).
ratti n.sp. (from *Rattus norvegicus,* Baltimore, U.S.A.)

For the sake of completeness it may be well to mention that species of Strongyloides of undetermined identity have been recorded also from the following animals:

Lemur, Weinberg and Romanovitch, 1908.
Fox, Romanovic, 1914.
Guinea Pig, Krediet, 1921.

Probably the final test of specificity among parasites is to be obtained from actual cross-infection experiments but there are a number of factors, some still of a theoretical nature, that enter into consideration here and unless taken cognizance of are liable to produce erroneous or misleading interpretations of infection experiment results. Some of these points will be discussed here.

Among parasitic nemadotes, species of certain genera are known to enjoy a very wide host range, sometimes extending through many orders or even classes. Thus *Trichinella spiralis* under experimental conditions can be established in most of the mammals, and under certain conditions even in amphibians. Other nematodes are able apparently to develop in a number of hosts that are more or less closely related zoologically.

Ancylostoma braziliense is reported from cats, dogs, man and other hosts. (See Darling, 1924.) *Ancylostoma duodenale* and *Necator americanus* on the other hand seem to exist normally only in man. This latter condition of host restriction is probably an index of the specialised nature of the particular parasite. Relatively little attention has been given until very recent times to the study of specificity among nematodes but in the application of parasitology to control work, it may become a subject of no little importance.

Among nematode parasites of plants, there are some such as *Tylenchus dipsaci, Heterodera schachtii* (Schm.) and *Caconema radicicola* (Cobb, 1925; syn. *H. radicicola*) which are polyphagous in their habits. When attempts are made to transfer some of these forms to other host plants, known to be attacked by the same parasite in nature, success does not always follow. Many interesting examples of this are to be found in the literature: Liebscher (1892); Goodey (1922), etc. Failures to infect certain plants of known susceptibility with the parasites are explicable only when the past history of the parasite is known and taken into account. It seems that the restriction of a population of parasites to a particular host species for a great number of generations leads to a special adaptation towards this species and a corresponding loss of adaptability towards other hosts. This loss may only be temporary but if the parasite be restricted for a sufficient number of generations the probabilities are that the loss will be permanent. The mechanism of this host restriction may be of the nature of a physiological ability to utilize food of only a particular chemical constitution. Should no somatic changes occur in the structure of the parasite during this time, an inability to establish it in its original host under experimental conditions would lead to its being considered as a biological variety but should morphological adaptations develop concomitantly with the development of a host specificity, the parasite would come to be recognized as specifically distinct from its parent stock.

The situation among nematode parasites of animals is, I believe, closely analogous to that which obtains among nematode plant parasites. The development of structural differences in certain groups of nematodes which parasitise different hosts is sometimes of a low order. The degree in which it occurs may depend on several factors, such as the intrinsic plasticity of the parasite, the extent to which the change in environment in a new host calls for special adaptations, an evolution time factor, as well as upon other factors of a more obscure or less intelligible nature. Several intermediate gradations may be recognized in the evolution of a complete specificity of a parasite towards its definitive host. When embryonated eggs of several species of Ascaris are fed to abnormal hosts, the larvae which hatch from the eggs undergo the normal migration through the vascular system and lungs but when they return to the

intestine, they are unable to establish themselves and are passed out of the body. The parasite shows different degrees of adaptation to different host animals. In some animals (rats, guinea pigs, etc.) *Ascaris lumbricoides* is eliminated at an early stage, while in other animals (sheep, goats) the larvae can develop to a stage approaching maturity before they are out of the intestine (Ransom and Foster, 1920). There are many who recognize a specific distinction between parasites which although morphologically indistinguishable appear to possess a high order of host specificity; thus for example *Ascaris lumbricoides* and *A. suum*. Although this procedure may not be warranted from the point of view of the systematist, from the standpoint of applied parasitology it is probably justifiable. The ability of a parasite to proceed to a certain stage in its development in an abnormal host may be further illustrated by the example of the human hookworm, *Ancylostoma duodenale*, which according to Looss and other observers (Looss, 1911: 328) is able to develop in young dogs almost to the mature stage before passing out of the abnormal host. In Strongyloides a most advanced condition is encountered; certain species, as will be shown later, develop to maturity in certain abnormal hosts and proceed to produce young but after a shorter or longer time the prolificity of reproduction gradually diminishes and eventually ceases, presumably with the death of the parasites. The mechanism of this dis-establishment is of great interest. There appears an interference with the reproductive functions and an inhibition of egg production in the earlier phases of the phenomenon. However, the matter merits further study and may yield interesting information on the subject of resistance and immunity to further re-infection. Such studies are now being prosecuted by the writer.

In making tests of the infectibility of abnormal hosts, certain conditions must be borne in mind. In the first place, it is necessary to use relatively large numbers of larvae in the infection experiment in order to allow for the relatively high rate of mortality among larvae (as much as 80% or more) which occurs even in the infection of normal hosts. To detect light infections, large quantities of feces must be cultured and carefully isolated. The period necessary for the maturation of the parasite may be the same as that required in the normal host (viz., 5 to 8 days) but it is sometimes prolonged. Because of this, as well as because of the transient nature of many of the infections, it is necessary to culture feces daily between the first and third weeks after the date of infection, before the results of an experimental infection of an abnormal host may be drawn. In addition a periodicity of egg production is also to be allowed for. Such a periodicity is noticeable in infections of normal hosts and attention has been called to it by many authors. As far as I have been able to see, this periodicity is not at all rhythmical. Throughout my experiments I have endeavored to use only young animals so

as to allow for a possible age resistance. However, in the case of man and some cats where only adults were available, no evidence of an age resistance was encountered.

In the following review of speciation in the genus, in addition to a discussion of morphology, results of experiments on the subject of abnormal host infections are also included. Living material of *S. stercoralis, S. fülleborni, S. cebus, S. papillosus* and *S. ratti* were available for experimental infections while specimens of *S. chapini* n.sp. *S. nasua, S. ovocinctus* and *S. suis* were kindly loaned me for comparative study by the Zoological Division, Bureau of Animal Industry, U. S. Department of Agriculture, from their helminthology collection.

Strongyloides cebus Darling, 1911.—The feces of three specimens of *Cebus hypoleucus,* the type host, were obtained and found to contain eggs of *S. cebus.* No specimens of the parasitic generation were available for comparative studies. The females of the bisexual or free-living generation do not have so prominent a vulva as is found in *S. fülleborni.* This is a constant difference between the two species and is the most prominent differential character. Attempts were made to infect two adult human volunteers with about 200 and 500 filariform larvae applied to the skin. In both instances stools were examined by the usual culture—Baermann—isolation technique from the 6th to the 17th day subsequent to infection but no evidence of the parasites having become established in this host was obtained. A species of Strongyloides is recorded by Leger (1921) from the following monkeys in French Guinea: *Midas midas, Ateles pentadactylus, Cebus apella.* The parasite was here described as *S. stercoralis* but in my opinion it is more probably *S. cebus.*

Strongyloides fülleborni von Linstow, 1905.—This species appears to be a very common parasite of Catarrhine primates. Von Linstow described it from *Anthropopithecus troglodytes* and *Cynocephalus babuin.* A species of Strongyloides has also been recorded from *Simia sinicus* L. (syn. *Inuus sinicus* Geoff.) by Gonder (1907) and from *Macacus cynomolgus, M. rhesus, M. nemestrinus* by Weinberg and Romanovitch (1908). Since I have found the species involved in infections of 2 specimens identified as *Pithecus rhesus* (syn. *M. rhesus*) and one specimen of *Macacus* sp. I think it probable that *S. fülleborni* is the species involved also in the infections of the above hosts. Linstow (1905) states that only larvae are found in the fresh feces of monkeys infected with *S. fülleborni* but from the context of the paragraph it is evident that he intended to state that only eggs are found in fresh feces. This is a constant character and of value in diagnosis. The parasite according to von Linstow measures 3.78 mm. in length. In my material from *P. rhesus* mature parasites ranged in length between 2.02 and 2.85

mm. As already stated the ovaries of the parasitic female of this species are of the sinuous type. In cultures of material containing *S. fülleborni*, development was found to be exclusively or almost exclusively of the indirect type. A number of infection experiments were undertaken with filariform larvae of *S. fülleborni* the results of which are recorded here.

1. *Ateles geoffroyi.* A very few larvae were isolated from large cultures of the feces of this animal (a young specimen) on the fifth and sixth days after skin infection with about 600 filariform larvae. Despite reinfection with large numbers of larvae (about 3,000) on two subsequent occasions no further establishment of adult parasites could be demonstrated. The animal was killed six days after the last infection but a careful examination of the intestine disclosed no worms. This experiment seems to support the view that the species of Strongyloides of the Old and New World are distinct.

Infection of dogs.—Dog 1. This animal was infected by skin with about 5,000 larvae. A very light infection was demonstrable by the fecal culture method on the sixth and seventh days subsequent to the day of infection. After the seventh day all further cultures were negative. Dog 2. Similar results were obtained in this dog as in dog 1 except that a culture on the eighth day yielded a few larvae.

Infection of man.—Two adults volunteered to receive infections with *S. fülleborni;* 45 and about 250 filariform larvae were applied to the skin on the forearm respectively. In both subjects a small infection was demonstrable in the cultures on the eighth day but not subsequently.

Infection of cats.—Two cats were infected with large numbers of filariform larvae from feces of *Pithecus rhesus.* About 5,000 larvae were placed on the shaved abdomen of one cat and about 20,000 larvae on the abdomen of the other. No infection could be demonstrated in either case by cultures made over a period of two weeks. The cat on which the larger number of larvae were placed was killed at this point but no parasites were found in the intestine.

Infection of rats.—Four rats were infected, each with 200 larvae but no infection was established in any of these animals.

Strongyloides nasua DARLING 1911

Type material deposited by Darling in Washington was available to the extent of four specimens of the parasitic generation. The specimens were all mature and measured from 1.75 to 2.20 mm. in length. The preservation of the material was, however, poor and the course of the ovaries could only be followed in two specimens in which the ovaries were directly recurrent forming "hair-pin bends." I was unable to find a small posteroanal papilla as described by Darling, but this may have been due to the unfavorableness of the material. Morphologically,

it is difficult to distinguish between *S. nasua* and *S. stercoralis*. It would be necessary to have more material and to carry out cross infection experiments to determine the correct status of this species.

Strongyloides ovocinctus RANSOM 1911

The material from which this species was described was made available to me through the kind courtesy of Dr. B. H. Ransom. The material was in abundance and had been collected by Dr. Albert Hassall from a Prong-horned antelope, *Antilocapra americana*, which had died in the National Zoological Park in Washington, D.C. Ransom erected this species on the basis of its laying eggs in strings. Otherwise no difference was found between this form and *S. papillosus*. Ransom thought that the tube in which the eggs were found was produced by a sloughing of the cuticula and the lodging of the eggs in this structure after they passed out of the vagina. The adult worm would thus appear to undergo successive moults. If this were so, the phenomenon would seem to be unique among nematodes, since the present conception is that no further ecdyses occur after the worm has attained the adult stage. An examination of the so-called outer cuticular layer of *S. ovocinctus* shows it to be devoid of striations while the real cuticula underneath is plainly striated. This is contradictory to the idea of the structure being a shed cuticula. A similar condition is noted in *S. papillosus* of sheep by Brumpt (1910 : 431 ; fig. 270) who interprets the sheath as the body of the dead worm or as the everted uterus. The pathological condition of the material is thus indicated. An inability to stain the somatic nuclei in specimens of *S. ovocinctus* together with other evidence makes me inclined to believe that this material was not killed and preserved in the living condition. In examining fresh material of *S. papillosus* from rabbits and sheep, I have never found the eggs within a tube. The eggs are laid in strings of varying lengths in all the species I have examined (viz., *stercoralis, fülleborni, papillosus* and *ratti*) but the tube-like structure which holds the eggs together is of a gelatinous consistency and observed during the process of egg formation and deposition in living specimens, is seen to consist of a clear mucilaginous substance secreted by the walls of the uterus. In the mucosa of infected animals, such strings of eggs of varying lengths are always found. The ovaries of *S. ovocinctus* also resemble those of *S. papillosus* in being sinuously disposed. The size of the parasitic generation also falls within the range of *S. papillosus* and consequently there is little if any substantial morphological support for a specific distinction between the two forms.

Strongyloides papillosus (WEDL 1856) RANSOM 1911

This species has been recorded from sheep, goats, rabbits and, according to the host list given by Hall (1916), also from rats and other

rodents. The synonomy of this species includes *S. longus* (Grassi, 1885), a name which answered the description of an *omnium gatherum*. The parasite had a loose and inadequate description prior to that given by Ransom (1911) to whose description I am unable to add anything new. Infections in sheep may be transferred without difficulty to rabbits and become permanently established.

Strongyloides ratti n.sp.

A species of strongyloides "a little smaller than the human species" was recorded by Grassi and Segré (1887) from *"Mus sylvestris"* in Rovellasca. The authors thought that this parasite might be a distinct species. They further found a form "about the size as the human species in *"Mus decumanus"* in Catania. No further description is given of this parasite. Hall has included the form in the rat under *S. papillosus*. Repeated attempts to infect rabbits with filariform larvae from the rat and to infect rats with larvae from rabbits were unsuccessful and this was taken to indicate the duality of the two forms, a view that later received support from morphological studies. The parasite occurs in about 60% of rats caught on refuse dumps in Baltimore.

The parasitic generation, represented by females, range from 1.85 to 3.03 mm. in length. The average of 14 mature individuals gives a length of 2.35 mm. The cuticula when observed under high magnification is seen to be finely striated transversely. The buccal cavity is very shallow and surrounded by six minute papillae. The esophagus varies in length from 0.55 mm. to 0.78 mm., average 0.665 mm. (or expressed as a percentage of total body length, 22.2 to 33.0%, average 28.12%). The vulva is situated from 1.27 mm. to 1.73 mm. from the anterior end and its lips are slightly elevated. There may be as many as eleven eggs in both uteri at one time. The ovaries in all but a few of the specimens examined are directly recurrent, the bends being close to the esophageal and anal ends of the intestine (Pl. IX, *A*). The anus is situated 32 to 50 μ from the posterior end of the body. The tail in most specimens is finely tapered. (Pl. VIII, row 4. Eggs measure 47 to 52 μ by 28 to 31 μ. The filariform larvae range in length from 0.560 to 0.736 mm. (average, 0.651 mm.) and in maximum breadth from 0.17 to 0.21 mm. There is nothing to distinguish the males and females of the bisexual generation from those of *S. papillosus*. Males average 0.820 mm. in length and 0.038 mm. in breadth at the esophageal end of the intestine. The females are larger: 1.12 to 1.2 mm. in length and 0.04 mm. in breadth at the base of the esophagus. The eggs of the rhabditiform generation measure on the average 40 by 30 μ.

S. ratti is distinguishable from *S. papillosus* by a combination of the following differential characters: smaller size, finer striations of the cuticula and the course of the ovaries. Unsuccessful attempts were

made to infect the following animals with fairly large numbers of larvae of *S. ratti,* young animals being used for the purpose: 4 rabbits, 2 guinea pigs and 6 mice. As regards the latter animals, it seems possible that the prolonged passage of the parasite through rats may have produced a rat-restricted population which might account for its inability to establish itself in an unusual host, even though this may be closely related zoologically to the normal host.

Strongyloides suis (? LUTZ 1885) VON LINSTOW 1905

A species of Strongyloides was recorded by Grassi (1884) from rabbits, sheep, weasels and pigs. This species was named *S. longus* and was distinguished from *S. stercoralis* for the following reasons: larger size (up to 6 mm.), presence of eggs instead of larvae in fresh feces and because the free-living generation was somewhat smaller. In 1885 Lutz, apparently unaware of Grassi's paper, reported the finding of a new species of Strongyloides in pigs in Brazil. The parasite was, however, not described except to mention that it was larger than *S stercoralis* and that eggs were present in the feces. Nor did Lutz give the parasite a name. Von Linstow (1905) in listing the various species of Strongyloides described up to that date, refers the parasite found in pigs, sheep and rats to *S. suis* Lutz without further comment. In a search of the literature I have been unable to find any justification for von Linstow's action. Since it has been the practice of some workers to ascribe a new specific name to Strongyloides merely because of its occurrence in a new host together with perhaps a size difference, the specific rank of *S. suis* becomes questionable. In four specimens of the parasitic generation loaned from Dr. Ransom's collection, the length of the parasite ranged from 3.86 to 4.05 mm. In those specimens in which the ovary could be clearly distinguished, it was seen to be sinuously disposed as in *S. papillosus.* The only possible distinction that could be made between these specimens and *S. papillosus* would be on the basis of a more acutely pointed tail in *S. suis* but as this character is very variable, the distinction between *S. suis* and *S. papillosus* on morphological grounds is uncertain.

Strongyloides westeri IHLE 1917

This is the largest species of Strongyloides yet recorded. The length according to Ihle is 8 to 9 mm. and breadth 80 to 95 μ. Eggs only are found in the feces (Wester, 1918). From the description *S. westeri* differs only from *S. papillosus* in the matter of size. Development is predominantly direct but the bisexual generation has also been found (Blieck and Baudet, 1919). These authors (1921) failed to infect a dog with large numbers of filariform larvae of *S. westeri.*

Strongyloides chapini n.sp.

This parasite was collected by Dr. E. A. Chapin from a specimen of *Hydrochoerus hydrochoera* which had died in the National Zoological Park, Washington, D.C. Three specimens were available for examination. Their lengths were 3.80, 4.43 and 5.52 mm. and the width at the base of the esophagus 0.026, 0.028 and 0.028 mm. respectively. The width of the body at the level of the anus was from 0.014 to 0.019 mm. The shape of the tail is depicted in Plate VIII, row 6. The three specimens were covered with ciliates, eggs and larvae which adhere to the body, obscuring much of the internal organs in the region where the vulva is located so that the position of this organ cannot be given in this description. The adhesiveness is apparently a post-mortem sequel due probably to an exudate similar to that which is found in the posterior part of the body of "*S. ovocinctus.*" The anterior and posterior ovaries are partially visible in all three specimens and seem to take the form of "hair-pin bends." It is only on the basis of this character that *S. chapini* is distinguishable from *S. papillosus.*

Strongyloides vituli BRUMPT 1921

A species of Strongyloides to which Brumpt assigns the name *S. vituli* is recorded from calves in Paris (Brumpt, 1921a). No description of this form accompanies the record. According to Stiles and Hassall's Index Catalogue, a species, to which the name *S. longus bovis* is assigned, has already been recorded from *Bos taurus* in Turin by de Gaspari.

Strongyloides siminae HUNG AND HÖPPLI 1923

This species was tentatively created by the authors for a Strongyloides from *Macaca* sp. on the basis of various characters wherein they considered their parasite did not conform with the descriptions of *S. fülleborni* and *S. cebus.* I have already discussed these characters and as a consequence do not feel that the authors have made out a clear case in distinguishing *S. simiae* from the other two species already described from primates.

Strongyloides stercoralis (BAVAY 1877) STILES AND HASSALL 1902

This is the type species of the genus and is well known.

A species of Strongyloides indistinguishable from *S. stercoralis* was found by Fülleborn (1911 and 1914) in dogs from China and Japan. Apparently the same species is described by F. and M. Ware (1923) from a dog in India. Fülleborn showed that *S. stercoralis* from man was infective for dogs but he found that after a course of two to three weeks the infection disappeared spontaneously (Hung and Höppli, 1923: 119).

In consequence of this disappearance Fülleborn thought that the parasite which is found as a presumably "permanent" parasite of dogs in the Orient might be a biological variety of *S. stercoralis*. Thira (1919) was able to infect cats and apes with *S. stercoralis* in Japan but nothing is noted for the duration of the infections in the experiment. In view of Fülleborn's statement of the transient character of the infections, the writer commenced infection experiments to see whether it was possible to produce a permanent *S. stercoralis* strain in dogs by repeated passage of the parasite. Three dogs were infected at various times with material derived from a human case in Georgia. In the first dog, many thousands of filariform larvae were placed on the abdomen. In about seven days when the infection became established, infective larvae were isolated from the cultured stools and used to reinfect the same dog. This was repeated again after the lapse of nearly two weeks after which time no further reinfections were given. The animal died nearly eight weeks after the last infection and very large numbers of parasites were found through out the small intestine at autopsy.

A second dog was infected with about 800 filariform larvae from the same human case. The infection that became established in this animal was at no time very intense as measured by the numbers of larvae that were isolated from fecal cultures. The infection gradually decreased in intensity with the passage of time but when the feces were last examined by the culture-isolation method 301 days after the infection of the animal, Strongyloides larvae were still found in appreciable numbers.

The third dog was infected with about 500 filariform larvae from the second dog in this series. Larvae were found in fecal cultures, nearly twenty weeks after infection and a number of parasites were found in the intestine when the animal was sacrificed.

The difference between Fülleborn's experience and my own can, I think, be accounted for by the fact that I used the Baermann isolation technique in the examination of the fecal cultures, a method that is far superior to the method of examining cultures directly without isolation. In this way, larvae are easily detectable after the intensity of the infection has dropped off.

The falling off of the infection may not be so insignicant as it at first seems but may be of general application. On February 17, 1925, the writer infected himself with 20 filariform larvae of indirect development derived from the third dog in this series. A single rhabditiform female was found in a fecal culture made on Feb. 25. On Feb. 27 and 28 more individuals of the rhabditiform generation were isolated from cultures but no further evidence of an infection was obtained in subsequent cultures made at frequent intervals for two weeks thereafter. In this case, the parasite appears to have undergone some biological change in the

course of its establishment in an unusual host for such a short period as two generations.

Three cats were infected with larvae of *S. stercoralis* from the dog, two of these animals were fully grown while one was about three months old. The infections established were all relatively light and as long as thirteen days elapsed after infection before larvae could be isolated from fecal cultures. The infections commenced to fall off considerably two to three days after the parasites had become mature but larvae did not disappear entirely from the feces until after the eleventh day. One might tentatively conclude from these experiments that *S. stercoralis* is not a normal parasite of cats.

Strongyloides canis BRUMPT 1922

Although no morphological differences could be found by Fülleborn (1914) between *S. stercoralis* and the form that occurs as a natural parasite of dogs in the Orient, Brumpt (1922 : 694) for various reasons considers that the parasite of dogs is distinct specifically from that of man. He brings forward the following arguments to support the contention of the specific distinction of *S. canis* and *S. stercoralis:*

1. A presumable difference in the geographic range of Strongyloides infections in man and dogs.

2. The difficulty experienced in the infection of dogs with *S. stercoralis* as noted by Grassi and by Braun.

3. The fact that in infected dogs from the Orient, Fülleborn found development to be only indirect while Brumpt in unpublished researches found that in dogs infected with larvae from a human infection, both direct and indirect development occurred.

The third argument offered by Brumpt cannot be discussed here since the details of his experiments are not available. It can be pointed out, however, that a change in the general trend of development when infections of Strongyloides are transferred from one host to another, not necessarily a new host-species, does not indicate the non-specificity of the parasite for the new host. (This subject has received treatment in another paper now in press.) It is scarcely permissible to conclude that the appearance of males in fecal cultures from a rabbit infected with *S. papillosus* derived from a sheep in the cultures of which only females of the rhabditiform generation were found, is evidence of a difference in the species of Strongyloides that naturally infest sheep and rabbits (Brumpt, 1921b). In my opinion the only consideration that might be indicative of an abnormal host-parasite relationship, would be the inability of the parasite when introduced under the proper conditions to mature and establish itself for a fairly long time in a new host species. Thus, I consider the inability of the parasites of rabbits and

rats to establish themselves in each other's hosts indicates a specific distinction. The transient character of the establishment of *S. fülleborni* in man and dogs is also evidence of an abnormal host-parasite association. However, even such evidence must be interpreted with caution in view of the possibility of other factors in the genealogy of the parasite being involved. Brumpt might have brought forward the evidence of *S. stercoralis* not producing a permanent infection in dogs when introduced from man. However, as already stated, my experience in this connection does not coincide with that of Fülleborn. As regards the difficulty experienced by Grassi and by Braun in infecting dogs with *S. stercoralis*, the evidence is hardly applicable. The attempts to infect dogs by both of these investigators were made before the cutaneous method of infection was known and both investigators attempted without success to infect dogs by mouth. Braun (1899) fed a dog with filariform larvae contained in milk. My experience has been that the cutaneous mode of infection was much superior to the administering of larvae by mouth. There are at least two possible causes for failures in infection experiments:

1. It is necessary even by skin infection to use a relatively large number of larvae, since a great percentage always perish for various reasons before the worms reach maturity and establish themselves in the intestine.

2. To demonstrate light infections careful culturing and isolation of feces is necessary. Using the Baermann isolation technique, no difficulty was experienced in the detection of infections in dogs with not more than 200 infective larvae of *S. stercoralis*.

With regard to Brumpt's reference to the apparent differences in geographical distribution between *S. stercoralis* and Strongyloides infections in dogs, the evidence is again not clear. The spread of Strongyloides infection even in man depends on a number of factors chief among which is the extent of soil pollution and the degree in which the social habits of a population make the contracting of infections possible. The incidence statistics for Strongyloides as I have pointed out in a previous paper (Sandground, 1925) are really very unreliable and the probabilities are that infections with this parasite are much less common than at present reputed.

As a general rule, few examinations of dogs are made for Strongyloides infection in countries where *S. stercoralis* is prevalent and thus little if anything is known of the incidence of infection among dogs. Even should the incidence of Strongyloides among dogs be found to be low in communities showing a high *S. stercoralis* incidence, it would be possible that the habits of dogs in these communities of avoiding contact with night-soil contaminated areas would account for the relative difference in the incidence and also for differences in geographical distribution.

In consideration of the foregoing arguments, I must question the validity of the action of distinguishing between the species of Strongyloides in man and in dogs and prefer to regard the parasite of dogs as identical with *S. stercoralis.*

SUMMARY

1. In a comparative study of various morphological characters that have been used for the erection of new species in the nematode genus Strongyloides, it is seen that the range of variation is so great that few species can be definitely differentiated on the basis of these characters. The practice of erecting new species on the basis of the size of the parasite and on the fact of its occurrence in a new host is critically discussed and the opinion is held that such a practice is weak.

2. The specificity for their hosts is regarded as the best means of determining the specific standing of the parasites but it is necessary to observe certain considerations in the interpretation of results of infection experiments.

3. From a morphological standpoint, the validity of *S. ovocinctus* Ransom 1911 is questioned.

4. Dogs and cats have been infected with the human Strongyloides. The infections in dogs appear to be permanently established and since the parasite which occurs naturally in dogs in the Orient is morphologically indistinguishable from *Strongyloides stercoralis*, the parasite of dogs is held to be identical with the human form.

5. The parasite of rats is differentiated on morphological and biological grounds from *S. papillosus* from sheep and rabbits and a new species, *S. ratti* is erected for its reception.

6. A new species from *Hydrochoerus hydrochoera* is described and named *Strongyloides chapini.*

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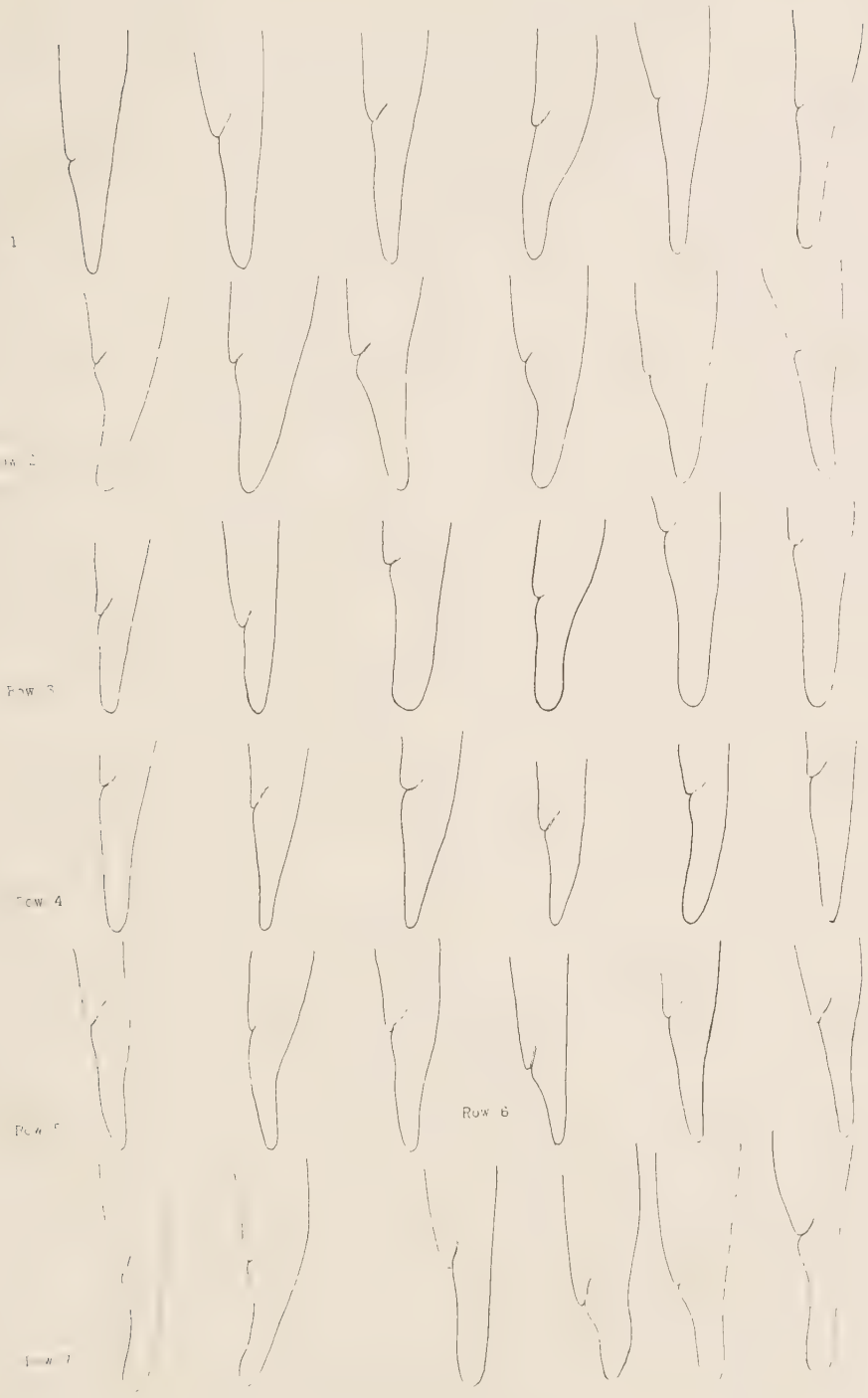

PLATE VIII

Explanation of Plate VIII

Camera lucida drawings to show the variation in the shape of the tail and the distance between the anus and posterior extremity of the body of the parasitic generation in various species of Strongyloides.

Row 1—*S. stercoralis;* Row 2—*S. fülleborni;* Row 3—*S. papillosus;* Row 4—*S. ratti* n.sp.; Row 5—*S. nasua;* Row 6—*S. chapini;* Row 7—*S. ovocinctus.*

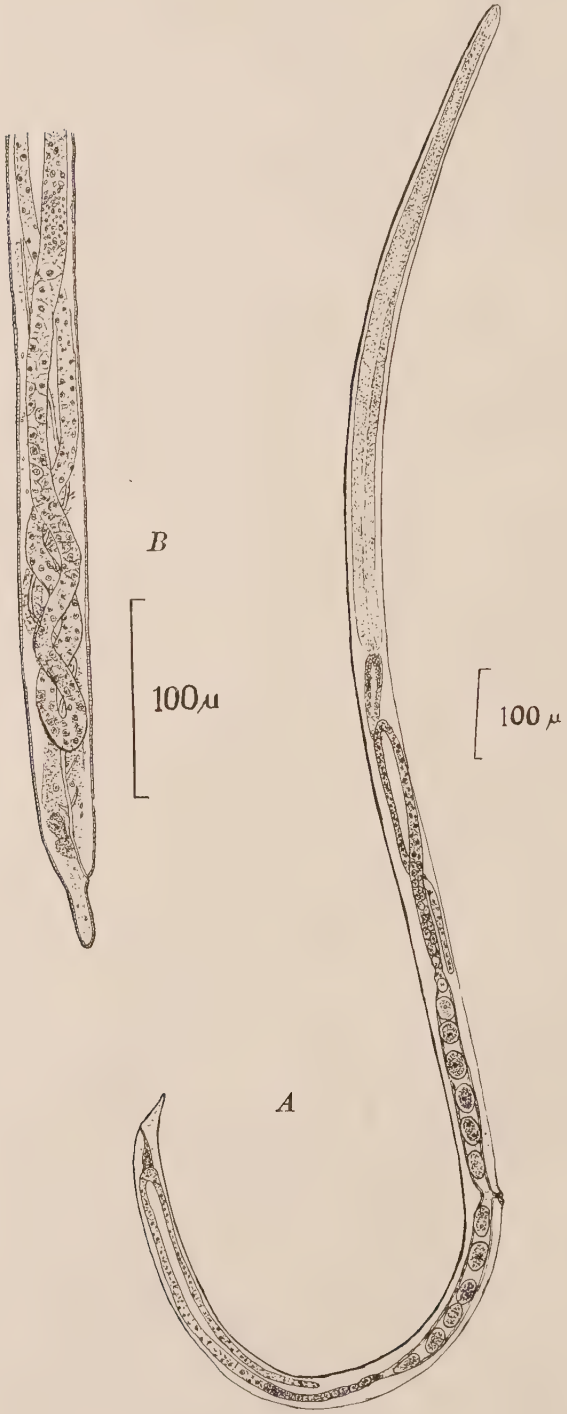

PLATE IX

EXPLANATION OF PLATE IX

A. *Strongyloides ratti* n.sp. Parasitic female; showing the "hair-pin bend" course of the ovaries.

B. *Strongyloides papillosus.* Parasitic female; posterior portion of the body showing the sinuous course of the descending and ascending limbs of the posterior ovary.

THE OCCURRENCE AND DISTRIBUTION OF *CYSTICERCUS CELLULOSAE* IN TEXAS SWINE

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Of the two species *Taenia saginata* and *T. solium,* infesting man, the former is conceded to be the more common form found in this country. To obtain an adult specimen of *T. solium* is usually considered a "find." From the number of carcasses and parts of swine condemned annually for "measles" by federal meat inspectors, it appears that the adult tapeworm must be more common than physicians and parasitologists realize. The object of this paper is to note the occurrence of *Cysticercus cellulosae* and to give an idea of its distribution in Texas.

In 1902, Dr. M. Francis was impressed with the relative frequency of this parasite in swine and, therefore, a record was kept by him of the specimens of measly pork sent to the College for diagnosis. The names and addresses of persons from whom the specimens were received were also kept as a part of the record. In 1919 these records were placed at the disposal of the writer and since that time additional data have been collected by him.

The number of specimens received during this period of twenty-three years has not been great and probably represents only a small number of the cases actually occurring. It is believed, however, that a tabulation of these data will give an idea of the distribution of this important parasite. The following table shows the number of cases recorded. The names of the persons submitting the specimens have been omitted for obvious reasons.

Year	County	Town
1902	Colorado	Eagle Lake
1911	Caldwell	Lockhart
1912	Frio	Pearsall
1913	Hardin	Evadale
1913	Frio	Pearsall
1914	Leon	Marquez
1915	Nacogdoches	Caro
1917	Frio	Pearsall
1917	Concho	Eden
1917	Hayes	San Marcos
1918	Kleberg	Kingsville
1918	Liberty	Dayton
1918	Jasper	Buna
1918	Bastrop	Smithville
1919	Bastrop	Smithville
1919	Waller	Hempstead
1919	Calhoun	Tivoli
1919	Montgomery	Fostoria
1919	Terry	Brownfield

Year	County	Town
1919	Robertson	Franklin
1919	Milam	Milano
1919	Falls	Otto
1919	Terry	Brownfield
1919	Gonzales	Waelder
1919	Mason	Katemcy
1919	Guadalupe	Seguin
1919	Madison	North Zulch
1920	Milam	Gause
1920	Jasper	Bessmay
1920	Jim Wells	Bentonville
1921	Tyler	Colmesneil
1921	Hidalgo	Mission
1922	Williamson	Liberty Hill
1922	Limestone	Cooledge
1922	Valverde	Comstock
1922	Hill	Hubbard
1922	Frio	Pearsall
1922	Gonzales	Nixon
1923	Falls	Rosebud
1923	Burnet	Marble Falls
1923	Atacosta	Lytle
1923	Fannin	Bonham
1923	Karnes	Runge
1924	Coleman	Santa Anna

In those cases where more than one record is from the same town, the specimens were sent in by different persons.

The reader will note that records are from thirty-six counties and to visualize the distribution, a map has been prepared showing the approximate location of the towns from which these cases are recorded. These counties, as a rule, have quite a large Mexican and negro population and to anyone familiar with the habits of these people, the reason for the prevalence of *C. cellulosae* in Texas swine is apparent.

Map of Texas showing distribution of *Cysticercus cellulosae*.

SOME NEW FEATURES OF NEMATODE MORPHOLOGY IN *PROLEPTUS OBTUSUS* DUJARDIN *

JUSTUS F. MÜLLER

In the course of a detailed study of *Proleptus obtusus* Dujardin, a nematode parasite of the dogfish, undertaken at the suggestion of Dr. Henry B. Ward, in his laboratory, some features of structure were discovered which have not been previously described for nematodes. Of these the most important had to do with the reproductive systems, especially that of the male, and with certain unicellular structures. The morphology of this form has been worked over several times, the most careful study being that of Seurat (1919). All of these descriptions, however, deal mainly with gross anatomy.

The male reproductive system in this species is unipartite. The testis is typical in shape. Its apex lies near the posterior end of the body some distance anterior to the genital pore. From here it extends forward about one third the length of the body, and loops back toward the genital pore. At its tip, just behind the apical cell its diameter is 15 μ. This dimension increases gradually along the length of the organ until at its base the diameter is 60 μ. This point lies on the backward arm of the loop about 6 mm. from the caudal tip. The vas deferens, vesicula seminalis, and ductus ejaculatorius follow in the usual order. The ductus ejaculatorius opens by a small longitudinal slit, about 15 μ long, into the cloaca on the ventral side, about 275 μ anterior to the anus (Figs. 1, 7, 8). The cloacal opening is separate from that of the spicule sacs. It is an arcuate slit lying on the anterior aspect of a mound-like elevation rising from the ventral surface of the body in the caudal region. At the apex of this elevation is a single circular pore through which the spicule sacs open together to the exterior (Text fig.). The spicule sacs are for the most part separate but unite just inside the common orifice. The distance between the anus and the orifice of the spicule sac is about 70 μ. The spicules are of unequal lengths. The right spicule is short and thick, the left long and needle-like, in the ratio of 1 : 4.8. The right spicule is about 413 μ long or one eightieth of the body length. It is straight and rigid compared to the left, and lies almost at right angles to the line of the body with its tip pointing ventro-posteriorly (Text fig.). Its proximal end lies very near the dorsal body wall and is slightly bent anteriad. Here the spicule has a diameter of 40 μ. This

* Contributions from the Zoological Laboratory of the University of Illinois, under the direction of Henry B. Ward, No. 270.

diameter is constant to the midpoint, where its dorsal wall collapses and the spicule tapers evenly to its tip. About 20 μ from its tip it is bent at right angles to the left and passes behind the left spicule.

The left or longer spicule is just short of 2 mm. long, or one sixteenth of the body length, and is about 40 μ in diameter. One third of its length from its distal tip there is a small cuticular tubercle upon its dorsal surface. Above this point the spicule is a tubular shaft; below it the tubular shaft is greatly diminished in diameter and lies along the dorsal surface of the spicule, while from its sides the outer layers of the spicule are inflated to form two lateral wings. Just at the tubercle these wings are directed sidewise, but they immediately bend ventrad so that their edges touch before they have descended the spicule 20 μ (Fig. 4). Thus is formed in their embrace a closed groove or canal along the distal third of the spicule, opening proximally at the level of the tubercle and distally at the point of the spicule where the wings disappear. This spicule, surrounded by its sheath, follows the course of the body until in the region of the cloaca, where it curves ventrally to the exterior. In so doing the sheath comes to lie very close to the dorsal surface of the terminal part of the cloaca. At a distance of 90 μ from the anus on the dorsal surface of the cloaca, and about 160 μ from the common spicule pore on the ventral surface of the left spicule sheath, the sheath and cloaca touch, and a short passage is opened between them connecting their lumina (Figs. 1, 2, 3).

Normally the cavity of the cloaca is in cross-section a horizontal slit about 145 μ wide, with its dorsal and ventral walls in such close apposition that its cavity is obliterated. However, between the opening of this duct or fenestrum communicating with the spicule sac, and the opening of the ductus ejaculatorius about 200 μ further anterior, there are small furrows or grooves on the inner surfaces of the dorsal and ventral walls of the cloaca. These grooves lie opposite each other to form a clear channel connecting the aforementioned openings; they are more developed posteriorly than anteriorly. There is a somewhat similar modification of the spicule sheath, the cavity of which above the opening of the duct is circular in cross section fitting tightly around the spicule. Below this opening, however, there is a large angle in the lumen along the ventral side, which forms a channel extending almost to the external opening of the spicule sac, where the lumen again constricts tightly about the spicule (Fig. 2).

Thus there is provided a continuous passage for the sperms from the cloacal opening of the ductus ejaculatorius, along the channel between the special grooves in the dorsal and ventral cloacal walls, out dorsally at the distal end of this channel through the passage to the spicule sheath, down the spicule sheath alongside the shaft of the spicule through the angle of the lumen, into the proximal opening of the channel

in the spicule (which has been exserted in copulation) and through the spicule channel into the female. This requires that the spicule be exserted until the proximal entrance to its lower grooved third be just within the external opening of the spicule sac. The tubercle occurring on the dorsal surface of the spicule at this point probably regulates this position.

Thus there is a distinct correlation between the separate openings of the spicule sacs and the cloaca, the shape of the longer spicule, and the special passage connecting the cavities of the sheath of this spicule and the cloaca. This passage way is a structure apparently not previously described. It is evident enough in complete serial sections but cannot be seen in toto mounts, and probably for this reason it has been overlooked by previous investigators. Its heavily cuticularized lateral walls continuous with the lining of the cavities of the spicule sac and cloaca are normally in close contact. The passage can be opened by means of small muscles attached to its lateral walls, and passing around the cloaco on each side to the body wall (Fig. 3. It may be called the cloaco-spicular canal.

Some peculiar features are to be found at the blind ends of the reproductive system in both sexes. The ovary at its apex has in general a diameter of 15 μ. About 15 μ from the tip its diameter tapers gradually to form a slight neck (Fig. 5) about 10 μ in diameter, and a bulbous tip about 13 μ in diameter. The end of the ovary for a length of 35 μ is hyaline, showing no affinity for stains either acid or basic, and toward the center of the bulb may be seen a large faint subellipsoidal nucleus, about 3 μ in diameter. Since no other nuclei are discoverable within this terminal hyaline portion it is probable that it is a single cell—the apical cell. This cell is rounded at its inner end or base, and abuts on the primitive ova, which appear abruptly and in number, and are arranged according to no special order, upward of fifteen in a single cross section. They are spherical, about 4 μ in diameter, and lie like potatoes in a sac. They show no gradual transition from the apical cell, and their haphazard arrangement is continued on down through the ovary. Thus there is no trace of a rachis. Approximately the same condition occurs in the male. Only in this case, the hyaline apical cell of the testis is short and hemispherical, with its flat side adjacent to the numerous primitive sperm cells. In neither sex could it be determined how the germ cells arose from the apical cell. Since the material used had not been fixed for cytological purposes it is possible that some post mortem change may have occurred in these delicate structures, but it is unlikely that the arrangement described could have been a complete artifact.

Some peculiar unicellular structures were also observed. Clusters of problematical small cells are scattered in the anterior lateral and median lines. There are two cells, however, in the lateral lines which

are very striking because of their large size (Fig. 10). These lie between the dorsal and ventral halves of the line, about 75 μ behind the cerebral ganglion and in front of the excretory pore. In the male the cell body is 30 by 25 μ, and the nucleus is 10 μ in diameter, with a prominent nucleolus 4 μ. In the female the cell body is 50 by 33 μ, the nucleus being the same as in the male. Their deeply staining nucleoli are very striking. These cells are ovoidal, lying with their long axes in the plane of the cross section and passing through the ventral line. Their function could not be determined since fresh material was not available.

In the tail of the male two muscular bands, each a single cell, surround the posterior part of the intestine just anterior to the point where this merges into the rectum (Figs. 6, 7, 8). The anterior of these is the dilator cell. About 0.1 mm. posterior to this band, and just anterior to the junction of the ductus ejaculatorius with the rectum to form the cloaca, lies a second muscular band, which is of more regular and constant character. This is a new structure. It is 30 μ wide, about 8 μ thick and has a single spindle shaped nucleus lying ventrally on the right. It is compact, without processes, and like the former, with feebly developed muscular differentiation.

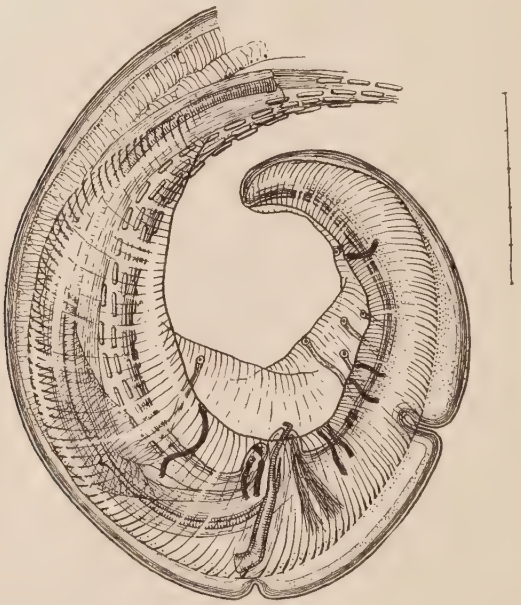
Beneath these two bands closely applied to the body wall is a large flat cell (Fig. 7), about 100 μ square, and of digitate outline, which sends processes from its lateral margins into the ventral walls between the muscle cells. Its protoplasm is weakly staining and fairly homogeneous, and the nucleus lies at the anterior edge. It may be of glandular nature. Two large pear-shaped cells lie one on either side of the cloaca just anterior to the canal connecting with the spicule sheath (Fig. 8). They are about 90 μ long. Although no ducts could be seen in these cells, their processes pass posteriorly along the lateral walls of the cloaca and it is probable that they are glands secreting into the cloacal passage. Other than these structures there are no anal or rectal glands.

In the tail of the female, with little modification the same two muscular bands can be found at a similar relative position. The anterior of these is a little more irregular, however, and tends to branch more over the intestine. Posterior to this is the second band, which is somewhat less developed, but withal similar to that of the male. The nuclei are ventral. In the female no unicellular glands were discovered emptying into the rectum.

Seurat (1919) pictures in connection with the female reproductive system one large unicellular gland posterior to the ovijector, but there are in reality many, collected in groups around the ovijector. The most definite of these is a pair of prominent cells lying immediately behind the ovijector. The larger of these is spherical, 45 μ in diameter, of granular structure, and with a prominent ellipsoidal nucleus 13 by 7 μ. Its cytoplasm is composed of an ectoplasmic layer 4 μ thick and more

darkly staining, and a somewhat lighter endoplasm, with a sharp demarcation between the two regions. The nucleus is central. A very evident duct passes from the center of the cell to the exterior, and into the angle between the posterior end of the ovijector and the body wall. Immediately to the right of this cell lies another, somewhat smaller, and pear-shaped. This is 15 μ in diameter and the length of its body is 22 μ. It has a conspicuous duct which parallels that of its mate.

In addition to these, two clusters of cells lie one on either side of the ovijector; on the left four distinct cells closely compressed to each other and to the wall of the ovijector, and behind these seven or eight smaller cells of indefinite shape. On the right in a similar position lie six cells.



Tail of male drawn from toto mount. Note lateral alae containing stalked papillae, the cloaco-genital mound, the two spicules, the longer showing a dorsal tubercle one third of its length from its point, and the separate openings of cloaca and spicule sacs. Scale: 0.5 mm.

Three are pear-shaped, 25 μ in diameter, and send processes into the angle on the right between the ovijector and the body. The remaining three are spoon-shaped, with their bodies cupped around the former, and their processes following a course similar to that of their mates. There is also an interesting lump in the wall of the ovijector, composed of a thickening of the syncytial layer that underlies the cuticular lining of its cavity. This node contains a constant number of nine nuclei. It is erroneously represented by Seurat as a single cell.

Some attention was given to the valve-like junction of the pharynx and intestine. Posterior to the brain ring the pharynx of this species has an outer granular and an inner muscular layer. The intestinal wall is composed of large columnar cells. The external diameter of the digestive tube in this region is 175 μ. The lumen of the pharynx is triquetrous, while that of the intestine is irregularly branched in cross section. A delicate cuticular sheath surrounds the entire digestive tube. At the level in question the lumen of the pharynx suddenly constricts (Fig. 9), about 170 μ anterior to the pharyngeal valve, so that its three folds are reduced from four-fifths to one half the radius. At this point also the delicate outer sheath sends inward two thin membranes, separated by about 20 μ. The anterior of these turns forward, about 40 μ and disappears. The posterior one curves slightly forward, and then backward, and disappears at the point where the triquetrous lumen of the pharynx gives place to the lumen of the intestine.

SUMMARY

1. The spicule sacs open in a common pore separate from and posterior to the cloaca. The left spicule has a channel along its lower portion opening at both ends. A previously undescribed passage way connects the cavities of the left spicule sac and the cloaca. A continuous passage is thus formed from the ductus ejaculatorius, along the cloaca, through the newly discovered canal, down the left spicule sac, and through the groove of the spicule for the discharge of the sperm.

2. No rachis was discovered in ovary or testis.

3. Peculiar unicellular structures include: two giant cells in the lateral lines near the head, an additional unicellular band encircling the posterior intestine behind the dilator cell, a large square cell lying ventral to these against the body wall, and two large pear-shaped cells, one on either side of the rectum.

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Explanation of Plate X.

Scale, 0.1 mm., except as stated otherwise.

Figures 1, 2. Wax reconstruction of cavities of cloaca and spicule sheath, etc., showing lumen of ductus ejaculatorius joining cavity of cloaca on ventral surface, and *cloaco-spicular canal* farther distal, connecting cloaca and left spicule sac. Anus and common spicule pore are indicated by heavy black lines. The left spicule is represented as exserted and cut off a short distance from the common spicule pore. Figure 1 seen slightly ventrally and from left; figure 2 from right. Note casts of grooves on dorsal and ventral surface of cloaca.

3. Cross section of male (ventral surface uppermost) in posterior region at level of *cloaco-spicular canal*, showing small muscles from this passage lateral to ventral body wall. Note also furrow on ventral wall of cloaca, almost obliterated here at posterior end of its course.

4. Successive cross sections of left spicule at intervals of 15 μ at proximal entrance to channel along distal third of its length, showing sudden origin and ventral bowing of lateral wings to form tubular modification of spicule.

5. Blind end of ovary showing clear apical area, apica cell (?), and numerous primitive ova arising abruptly and irregularly below same, without rachis. Scale: 0.01 mm.

6. Dilator cell of male surrounding lower intestine and ductus ejaculatorius, with processes passing to dorsal wall.

7. Composite camera lucida drawing of posterior intestine of male seen from ventral side, cloaca cut off just posterior to junction of dustus ejaculatorius with same. Note dilator cell, posterior to which is a second unicellular band, and large square cell ventral to these with processes severed just before they enter ventral body wall.

8. Same as 7, seen from left, showing entire cloaca with intermittent passage connecting with left spicule sac, and pear shaped cells on either side of cloaca at this level.

9. Digestive tube at level of pharyngeo-intestinal valve, showing sudden constriction of folds of pharynx and two cuticular membranes passing inward from outer membrane of digestive tube.

10. Cross section of worm anterior to excretory pore and 0.05 mm. posterior to cerebral ganglion, showing problematical large cells lying in lateral lines.

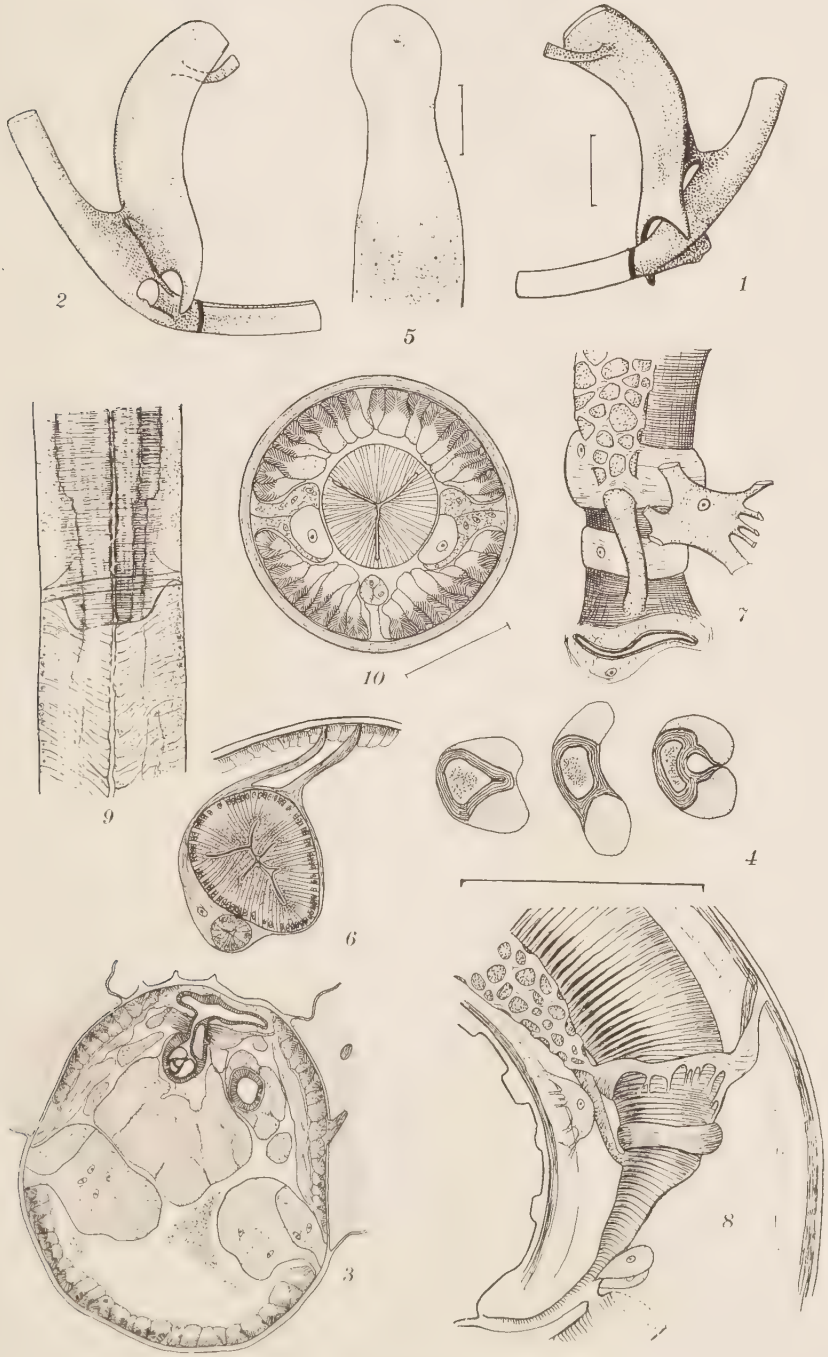

PLATE X

MESOCESTOIDES CORTI, A NEW SPECIES OF CESTODE FROM THE MOUSE*

R. J. C. Hoeppli

INTRODUCTION

A number of cestodes from a specimen of the common house mouse, *Mus musculus,* which were collected by Dr. W. W. Cort in 1909 at Colorado Springs, Colorado, were examined by me and proved to belong to a new species of the genus Mesocestoides. To this form I will give the name *Mesocestoides corti* n. sp. Recently Cameron (1925) has given a review of this genus and described two new species.

The genus Mesocestoides was erected by Vaillant in 1863 to include a species of cestode which he described from *Viverra genetta* as *M. ambiguus.* The fact that the validity of Vaillant's species is in doubt and that there is considerable confusion in regard to the identity of the various species which have been assigned to the genus Mesocestoides made it necessary to review carefully the available literature on this group. While final judgment on the relationship of these forms can only be passed by one who has the opportunity to study material of the different species, it has seemed worth while in connection with the description of the species to review the present state of knowledge of the group.

DESCRIPTION OF MESOCESTOIDES CORTI N. SP.

Altogether in the material from the mouse from which this study was made there were about one hundred specimens fixed with hot corrosive acetic solution. The average length of the mature specimens is between 4 and 8 cm. Figures 5 to 8 show the structure of this tapeworm as seen in toto mounts and figures 1 to 4 give further details from sections. The scolex is provided with large suckers the muscle ring of which is posteriorly incomplete. The neck is 1 to 2 mm. long. The first traces of the genitalia are visible before segmentation commences. The length of the first segment varies between 0.17 and 0.26 mm., its width between 0.493 and 0.544 mm. Gradually the length of the segments increases but even the hundredth segment is wider than long. The anterior margin of each segment is slightly shorter than the posterior one. Toward the end of the strobila the segments show a great variation in form, often having a cucumber seed-like appearance

* From the Department of Medical Zoology, School of Hygiene and Public Health, Johns Hopkins University, Baltimore, Maryland. I am indebted to Dr. W. W. Cort for the material upon which this study was based. I also wish to thank him for the generous assistance that he gave in the preparation of this paper.

(fig. 8). Others are round, some ovoid, some campanulated. The posterior part of the older segment in which the egg capsule is developed is rounded and broad, the anterior part long and thin. Also the increase in size of the segments shows no regularity in the posterior part of the strobila. Between a number of elongated segments one may find rather often some very short and broad ones. The uterus is visible as a dark median line in each segment.

The internal organization of the segments is typical of the genus Mesocestoides. The aperture of the genital atrium is nearly median and slightly anterior in each segment. Its walls are formed by radial muscle fibers. The opening of the cirrus pouch is in the center of the dorsal wall of the atrium. The length of the cirrus pouch compared with the ventro-dorsal diameter of the segment is about 1 : 2.5. The vas deferens is thick walled and forms many loops before entering the cirrus pouch. The testes vary in number between 36 and 60, there being about 40 in each segment. They are arranged outside and inside of the longitudinal excretory vessel on each side of the proglottis, but never lie entirely between these vessels as described by Cameron for *M. mesorchis*. The testes have an ovoid shape, measuring 26 by 34μ. They are often still visible in segments in which the ovaries have entirely disappeared. The vas deferens occupies a position in each segment dorsal to the uterus and vagina.

The female reproductive organs consist of an ovary composed of two round or oval connected halves, which are situated in the posterior part of the segment. Close to each half of the ovary at its ventral surface, a little toward the posterior end lies a vitelline gland, more or less round and slightly smaller than the ovary. The vitelline ducts and oviducts meet in the midline, where there is a small shell gland and also the communication with the uterus. The posterior part of the uterus has thick walls and is later transformed into the egg capsule. This process as well as the anatomy of the uterus is described in detail (1885) by Hamann for *M. lineatus*. Neumann (1896) points out for *M. lineatus* that the uterus is curved to the right or to the left of the cirrus pouch in more or less regular alternation in the strobila. This arrangement is also found in *M. corti*. The uterus with the exception of the posterior part is a long thin-walled tube showing a somewhat irregular form. As mentioned above, the vagina opens in the anterior wall of the genital atrium. It takes its course ventral to the vas deferens and dorsal to the uterus. In the posterior segments of a complete specimen one finds besides the egg capsule the remnants of the uterus, and usually also of the vas deferens and the cirrus pouch. Immediately behind the scolex there are two longitudinal excretory vessels on each side of the

neck. After a short distance only one on each side is present. They are connected in each segment by a wide transverse commissure.

The eggs have an oval shape measuring 19 by 24μ. They are a little larger than those of *M. litteratus* and much smaller than those of *M. lineatus*. They have a single thin shell. The life history of *M. corti* is unknown.

THE SPECIES OF THE GENUS MESOCESTOIDES

As mentioned at the beginning of this paper, the Mesocestoides species described by Vaillant from *Viverra genetta* remains a species inquirenda. The description of a species from the same host given by Weiss (1910) is also incomplete.

Most of the studies of the genus Mesocestoides have been based on *M. lineatus*. At the same time there is some confusion in the descriptions of this species and I have little doubt that a careful reexamination based on material from different hosts will make it necessary to separate the present species *lineatus* into two or more different species.

The length of *M. lineatus* shows a great variation according to the different authors. In this connection it should be noted that a typographical error in Cameron's paper (1925) gives as length in quoting Neumann's statements 30 to 250 mm.

Krabbe (1866) describes Taenia canis lagopodis from dogs and cats and canis lagopus in dogs in Iceland as having a length of 30 to 50 cm. to 1.30 mm. In cats the greatest length is about 65 cm., with the scolex 0.6 mm. wide, the suckers 0.25 mm. in diameter, the neck 0.45 mm. broad and 4 mm. long, and the last segments 3 to 3.5 mm. broad and 3.5 to 4 mm. long. In the young segments the testes are 50μ in diameter, the eggs measure 30μ in length and 25μ in width. Hamann (1885) gives a detailed description of *Taenia lineata* Goeze from a dog which had passed an anthelmintic treatment. In Hamann's material there was no scolex. The segments had a length of 2.34 mm. and a breadth of 1.3 mm.; the testes were 49 to 33 μ in diameter; the eggs 39μ long and 29μ wide.

According to Neumann (1896) the total length of *M. lineatus* varies between 30 cm. and 2.50 m.; the scolex is 0.9 mm. wide; the final segments are 2 mm. wide and 3 mm. long; and the eggs 35 to 43μ wide and 40 to 60μ long.

Setti (1897) described a species of Mesocestoides from *Lynx caracal* which he identified as *M. lineatus*. In the same he compared the statements concerning *M. lineatus* and *M. litteratus*. He came to the conclusion that the differentiation between *M. lineatus* and *M. litteratus* made by Zschokke (1888) and Condorelli Francaviglia (1891) was not justified. He not only found that these two authors were in disagreement as to the specific differences, but also discovered transitional

features in his own material. Setti gives as total length for his material 30 cm. The scolices are smaller than those described by other authors for *M. lineatus,* varying from 0.25 to 0.30 mm. in length and 0.33 to 0.40 mm. in breadth; the suckers show a maximum diameter of 0.15 mm.; the neck presents variations in length between 3 and 8 mm.; the diameter of the neck in the region of the scolex is 0.15 to 0.20 mm., while near the first proglottis it is 0.30 to 0.40 mm. The first distinct segment has generally a length of 0.05 to 0.10 mm., a breadth of 0.40 to 0.50 mm. The eggs measure 0.055 by 0,035 mm. in diameter. Cameron (1925) draws attention to the arrangement of the testes in each proglottis of *M. lineatus.* There are altogether about 50 testes which have their place outside and inside of the longitudinal excretory vessel of each half of the proglottis. He also finds a common opening of the male and female reproductive systems, whereas Zschokke and Neumann describe separate openings in close proximity to each other.

From the literature it seems evident that the material of Krabbe, Hamann and Neumann belonged to the same species *M. lineatus.* Concerning Setti's findings a reexamination of the material from *Lynx caracal* will perhaps reveal some differences which would make a separation from *M. lineatus* necessary. Scolex and suckers are considerably smaller than in the specimens of other authors, whereas the neck is comparatively long. Though I could not find definite differences in their internal organization I am certain that *M. lineatus* and *M. corti* must belong to different species. The differences in the total length, in the width of the scolex and especially in the size of the eggs are very great.

At present some helminthologists regard with Setti *M. litteratus* (*T. litterata* Batsch) as identical with *M. lineatus.* Zschokke (1888) and Condorelli Francaviglia (1891) made special studies of this parasite. Zschokke gives as total length 3.5 to 7.8 cm. with the average of 4.7 cm. The scolex is 0.4 to 0.7 mm. wide, the neck 0.7 mm. long. Condorelli. Francaviglia who collected material from *Canis vulpes* finds the length varying between 2 and 12 cm. The scolex is 0.6 mm. wide, the neck extremely short, being practically nonexistent. The last segments are 2 mm. wide and 3 mm. long, the eggs 15 to 17μ in both diameters.

I hardly need mention that in separating two species typical differences of one or several organs or differences of the whole internal organization are more valuable than mere differences in the length of the body. This is especially true in tapeworms which always show a considerable variability in their form. In the case of *M. lineatus* and *litteratus* distinct differences in internal structure could not be found. Nevertheless it can hardly be possible that the two species are identical. The total length of *M. litteratus* is very much less than that of the other

form, the neck is very short, and the size of the eggs is much less than the minimum size given by Neumann for the eggs of *M. lineatus.* In separating the two species I do not consider the different form of the scolex as pointed out by Zschokke as necessarily valid, because such a muscular organ may show great variations in form. On the other hand if one adopts the attitude that all these types belong to the same species *lineatus,* a species is formed the length of which would vary between 2 cm. and 2.5 m., the length of the eggs between 17 and 60μ. Even though one accepts a very great variability in *M. lineatus,* it seems to me that these variations are too great for a single species. Hamann (1888) who at the University of Göttingen had an opportunity to examine the specimens of the collection of Mehlis comes also to the conclusion that *T. lineata* and *T. litterata* are entirely different.

In internal structure there is no characteristic difference between *M. litteratus* and *M. corti.* They differ, however, in the length of the neck, the size of the mature segments and the size of the eggs. Besides this *M. corti* is a parasite of a rodent whereas *M. litteratus* is described from the dog and the fox.

M. longistriatus Setti from *Felis silvestris* and *M. mesorchis* Cameron have both a characteristic morphology and are certainly different from *M. corti.* The same is the case with *M. bassarisci* MacCallum (1921). *M. caestus Cameron* from *Mellivora ratel* ranges in its measurements within the limits of *M. lineatus.* With its total length of over 80 cm. it is very different from *M. corti.*

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Explanation of Plate XI

Reconstructions from sections of *M. corti*

Fig. 1.—Scolex, crossection.

Fig. 2.—Eight not fully mature segments, oblique section. In the most anterior segment the section lies close to the ventral surface, in the following segments the deeper structures are shown. *gp* genital pore, *t* testis, *ga* genital atrium, *v* vagina, *yg* vitelline gland, *ex* excretory vessel, *cp* cirrus pouch, *o* ovary.

Fig. 3.—Gravid segment, Sagittal section. *u* uterus, *ev* entrance of the vagina, *oc* cirrus opening, *d* vas deferens, *v* vagina.

4. One of oldest gravid segments, Sagittal section. *ur* remnant of the uterus, *ec* egg capsule, *cp* remnant of the cirrus pouch. Drawings 5-8 from toto mounts.

Fig. 5.—Scolex and neck, *s* sucker.

Fig. 6.—Immature segments.

Fig. 7.—Mature segments. *v.* vagina, *cp* cirrus pouch, *t* testes, *y* vitelline gland, *o* ovary.

Fig. 8.—Ripe proglottids of *M. corti*. *ur* remnant of the uterus, *ec* egg capsule.

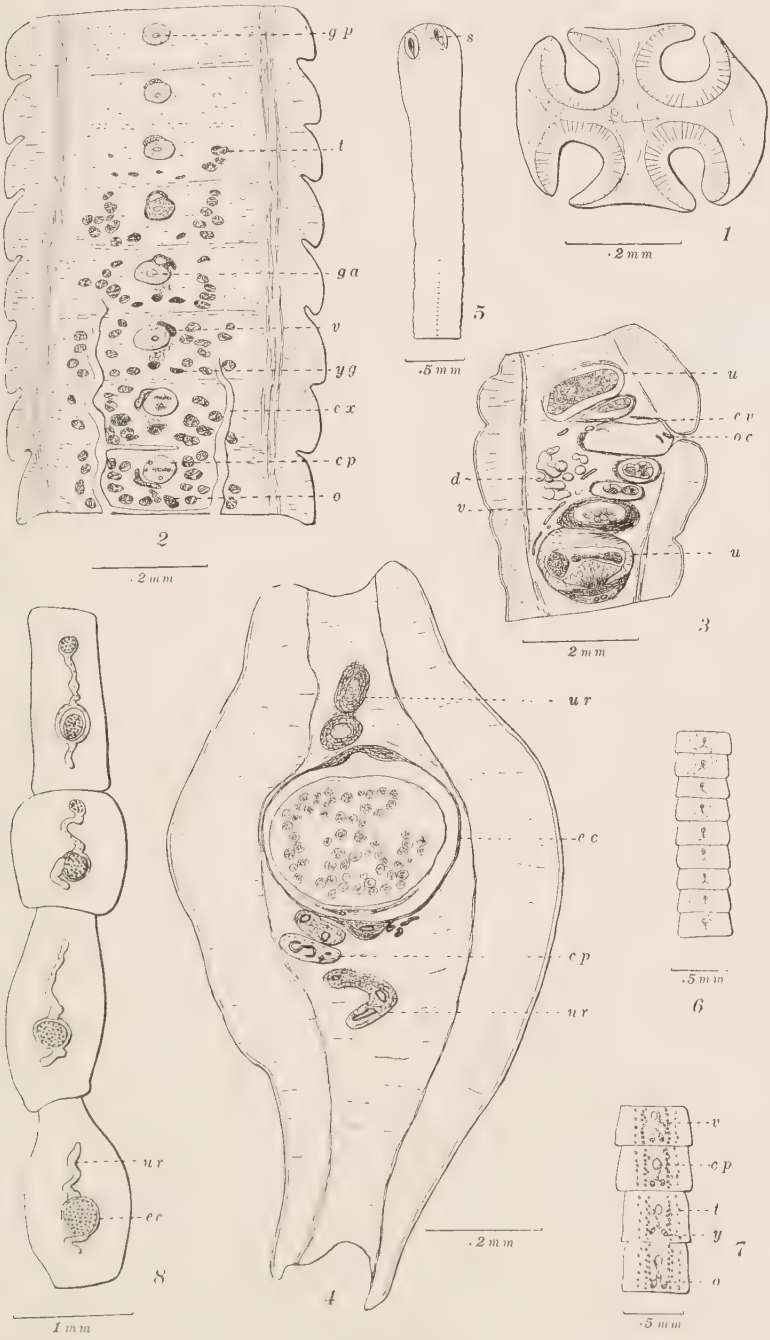
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PLATE XI

POLYMASTIX BUFONIS DOBELL, A FLAGELLATE FROM THE SALAMANDER AND THE FROG*

MISAO TANABE

In the larva of *Melolontha vulgaris,* Bütschli (1884) found a small oval flagellate with four equal flagella at the rounded anterior end, for which he established the genus Polymastix. Hamburger (1911) also described a flagellate from the larva of Melolontha. Mackinnon (1912) found a flagellate which she called Polymastix in the larva of the crane-fly *Tipula* sp., and later described, though not in detail, its life history. Franca (1913) described a Polymastix from the larva of Oryctes. These flagellates were all recorded from insects. Dobell (1909) and Alexeieff (1911), however, have described a flagellate from frogs and salamanders, which they placed in the genus Monocercomonas but which, according to Swezy (1916), who also studied flagellates from frogs and salamanders, should be removed to the genus Polymastix.

From April to November, 1924, I examined three salamanders (*Eurycea longicauda* (Green) near Baltimore, and many frogs (*Rana pipiens*) from New York. In two of the former and nearly all of the latter, a flagellate was found, that was identical in both host species and that belongs in the genus Polymastix. I have, however, observed several structural differences between these organisms and those described by Dobell, Alexeieff, and Swezy, and was able to make out in detail the division process which is recorded below.

THE ORGANISM

The flagellate moves by short jerks without changing the shape of its body. The flagellum is so thin that it can hardly be recognized in living specimens. The body is lancet shaped and measures 10 to 16 μ in length and 2.5 to 5 μ in breadth in the broadest part. The cytoplasm consists of periplast which stains pink with Wright's stain and endoplasm which stains blue; and there are many vacuoles of various sizes, especially in the posterior portion, but no bacteria nor solid substances; furthermore many delicate striations can be recognized on the body (Fig. 1). Dobell and Alexeieff did not describe striations. Swezy figures them distinctly, and suggested that other workers had overlooked them. The striations of the Polymastix from salamanders and frogs, according to Swezy, are apt to escape notice since "The slightly thickened periplast of the body is marked by striations which extend obliquely

* From the Department of Medical Zoology of the School of Hygiene and Public Health of the Johns Hopkins University.

across the body or in a nearly longitudinal direction. There appear to be thickened ridges or very slight folds in the periplast which do not show any definite staining reaction with iron hematoxylin. In many specimens, these striations may escape observation altogether." In an effort to make out striations, slides were made and stained to various degrees of density and a great number of organisms were very carefully studied. I could recognize striations with difficulty in a few instances on slides stained by Heidenhain's hematoxylin method, but was able to demonstrate them clearly on slides stained by Wright's method (Fig. 1). The striations appeared pink on the blue background of endoplasm in weakly stained organisms, but could not be seen in strongly stained specimens.

In the Polymastix studied by Swezy, there is a single granule, the blepharoplast, at the anterior end of the body from which arises four equal flagella. Alexeieff figures a number of granules. In the flagellate which I have studied there are two minute granules, somewhat rodlike, lying very close together one behind the other, at the anterior tip of the body (Fig. 3). This is the case in all individuals except a few where four granules are present (Figs. 4, 5); but this, as will be described later, seems to be due to a very early stage of division. From these granules, four flagella arise in two groups of two each; that is, a group consists of a flagellum from the anterior granule and one from the posterior granule (Figs. 2, 3). Swezy figures four flagella of equal length, but in my specimens one group is a little longer than the other, as described by Alexeieff. Slightly posterior to the granules is the nucleus. This has a thin nuclear membrane and the chromatin varies in its appearance. In a number of cases, it consists of a single mass, oval in shape, surrounded by a clear halo (Fig. 2); in other cases, two granules are closely connected or the chromatin may be diffused in a cloud as described by Swezy (Fig. 3). It was difficult to decide from a study of vegetative forms what was the structure of a typical nucleus, but after having studied dividing forms with a distinct structure such as is shown in Figure 9, it was clear that the typical nucleus of this organism is vesicular, composed of a thin nuclear membrane and a comparatively large karyosome (Figs. 2, 10).

Alexeieff found a darkly staining body near the nucleus in Monocercomonas and called it the "corps siderophile," while Swezy figured a body of various shapes in Polymastix and called it the "parabasal body." She says it is connected with the blepharoplast. This body exists in such irregular shapes as shown in Figures 2 to 5. I have noticed in some cases that the parabasal body seems to arise from the blepharoplast, but have never actually seen such a connection (Fig. 2). This body does not seem to dissolve in either acetic acid or sublimate, therefore it can be demonstrated in material fixed either in Schaudinn's fluid

or Flemming's solution. But it did not appear in a single instance in material which was dried and stained by Wright's stain (Figs. 1, 11, 12).

Alexeieff found cysts in his material and states that the cyst also has a "corps siderophile," while neither Dobell nor Swezy described cysts. I have also found cysts which are very similar to those described by Alexeieff. The cyst is round in shape and measures 3.4 to 4.7 μ. It has a delicate cyst membrane, but no flagella. The single nucleus is always situated eccentrically. The parabasal body occurs in every specimen stained by Heidenhain's method, but was not recognized in material dried and stained by Wright's stain (Figs. 11-14).

Alexeieff (1911) figures several dividing forms of *Monocercomonas bufonis,* while Swezy (1916) has worked out in detail the division process of *Polymastix bufonis.* According to her, the first evidence of division is the division of the blepharoplast, each new blepharoplast bearing two old flagella. Then the nucleus begins to divide mitotically, and the blepharoplasts separate by a simple constriction.

The division process in the specimens I have studied differs from that figured by Swezy. The nucleus does not exhibit any evidence of mitosis during the whole process of division. At first each of the blepharoplasts elongates slightly, distinctly exhibiting four granules, two in each blepharoplast (Fig. 4). Thus, two daughter granules, one behind the other, bearing two old flagella, go to each daughter organism, and afterwards one new flagellum grows out from each granule, completing the number. Next, the nucleus prepares for division; the karyosome increases its volume (Figs. 4, 5) and then elongates, finally becoming constricted in the middle (Fig. 6), and the nucleus elongates as a whole along with the karyosome, becoming dumb-bell shaped and finally separating into two (Figs. 7, 8), each of which has a long tail of chromatin immediately after separation but later becomes round like the normal nucleus with a thin membrane and a comparatively large karyosome (Figs. 9, 10). During the whole process of division, the nuclear membrane seems to remain intact, but I was unable to find any evidence of mitosis. The parabasal body seems to prepare for division a little later than the nucleus. This body becomes rod-like, constricts slightly (Fig. 6), and then elongates in the same direction as the nucleus (Fig. 7). At an early stage of division, it shows an irregular dumb-bell shape; as it elongates more and more, a long thread-like structure which persists for a long time connects the two ends; this still remains after the nucleus has completely divided (Figs. 8, 9). The cytoplasm then begins to divide at the anterior tip (Fig. 10) forming a groove which proceeds more and more towards the posterior end until finally the body is separated longitudinally into two parts.

No multiple fission has been observed.

DISCUSSION

The genus Polymastix was first established by Bütschli (1884), and its distinguishing characteristics are as follows: "Auf der Körperoberfläche bemerkt man eine verschiedene Anzahl dunkler und verschiedener langer Striche, die Bassi für trichocystenartige Gebilde zu halten gezeigt, während sie Kuntsler für Rippen der Oberfläche erklärt."

Swezy (1916) found a flagellate in frogs and salamanders and placed it in the genus Polymastix, owing to the fact that she was able to recognize striations, even if they were different from those described by Hamburger, Mackinnon and Franca. Swezy called her specimens *P. bufonis* Dobell, because she assumed that striations were overlooked by previous workers in both types of flagellates, one of which Dobell (1909) found in frogs and called Monocercomonas and the other Alexeieff (1911) found in frogs, Triton and Axolotl, placing it also in the genus Monocercomonas. The flagellate described in this paper is very similar to those of Dobell, Alexeieff, and Swezy. It possesses striations and in other respects is similar to *Polymastix bufonis* Dobell. Until further data are available therefore it seems best to call it by this name.

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EXPLANATION OF PLATE XII

Camera lucida drawings of *Polymastix bufonis* fixed in Schaudinn's fluid and stained with iron hematoxylin, unless otherwise indicated. Magnification × 1925.

Fig. 1.—Dry fixation and Wright's staining. Striations distinctly visible, but no evidence of a parabasal body.

Fig. 2.—Showing a vesicular nucleus and an S-shaped parabasal body.

Fig. 3.—Chromatin diffused; parabasal body O-shaped.

Fig. 4.—Beginning division of blepharoplasts.

Fig. 5.—Blepharoplast divided.

Fig. 6.—Nucleus elongated.

Fig. 7.—Advanced stage of division.

Fig. 8.—Parabasal body much elongated.

Fig. 9.—Division of nucleus completed, of parabasal body unfinished.

Fig. 10.—Late stage of division.

Figs. 11-12.—Dry fixation and Wright's staining. Cysts: no parabasal body.

Figs. 13-14.—Cysts with parabasal body evident.

PLATE XII

THE CULTIVATION OF TRICHOMONADS FROM MAN, RAT AND OWL*

MISAO TANABE

Lynch (1915) first reported the successful cultivation of Trichomonas from the vagina and the mouth, and also from the intestine of man. A number of investigators later cultivated trichomonad flagellates from man and other animals; among them were Ohira and Noguchi (1917), Reuling (1918), Hogue (1921), Reichenow (1923) and Kofoid and Swezy (1923). Hegner and Becker (1922) and Reichenow (1923) suggested the advantage of the culture method in the diagnosis of trichomonas infections of man.

The culture media reported by these investigators are all similar; they are made of a salt solution containing nutrient material such as serum or ascitic fluid. In such media, trichomonad flagellates will grow and multiply, but at the same time, bacteria also increase rapidly in numbers. Considering that the types of bateria in the intestine of animals depend a great deal, even in the case of the same individual, upon what these animals eat; it is not probable that every worker will get the same results as those obtained by previous investigators. If bacteria which are harmful to the protozoa are prevented from growing or at least if their growth can be prevented to some extent by measures which have no influence on the vitality of the protozoa, trichomonads can then be cultivated with certainty.

During my experiments, I was able to cultivate a certain species of Trichomonas from the rat with certainty more than twenty times for about six months. The principal object of this paper is to bring this culture medium to the attention of students who may wish to use it in the cultivation of other intestinal protozoa.

White of egg is known to have a powerful bactericidal action on some kinds of bacteria. This fact led to its use as a culture medium for protozoa. The culture medium finally evolved is as follows:

NaCl	0.7 g.
Sodium citrate	1.0 g.
Löffler's blood serum (dehydrated)	0.5 g.
White of egg	2 c.c.
distilled water	100 c.c.

First the salts are added to water and entirely dissolved; then the white of egg is added, and the solution is vigorously shaken in order

*From the Department of Medical Zoology of the School of Hygiene and Public Health of the Johns Hopkins University.

to distribute the egg-white homogeneously; Löffler's blood serum is then added; the medium is shaken again; and is tubed with about 10 c c. in each test tube.

OBSERVATIONS ON THE CULTURES

Material from the cecum of the rat was inoculated into the culture medium, and incubated at 35 C. Twenty-four hours later, the medium showed a slight increase of turbidity and Trichomonas had multiplied both on the surface and on the bottom of the medium, slightly more at the bottom. At the same time the bacteria multiplied, but so little that the medium was nearly transparent and showed no evidence of putrefaction. Forty-eight hours later, the organisms reached their greatest period of multiplication, and at this time, they grew much more abundantly at the bottom of the medium than on the surface. The medium showed the same turbidity as after twenty-four hours, and had no odor. At this time the organisms seemed to stop multiplication; became less abundant after seventy-two hours; and decreased day after day, finally disappearing in about one week. If transfers are made every three days, the strain can be maintained for a long time; perhaps indefinitely.

KIND OF TRICHOMONADS GROWN IN THE MEDIUM

As will be described in another paper, I have found four different kinds of trichomonad flagellates in the rat, and after many trials found that only one of them multiplied in the medium. This organism is small and has five anterior flagella. During these studies I had an opportunity to obtain a trichomonad from an owl (to be described in another paper) and Pentatrichomonas of man, (also to be described in another paper) and succeeded in cultivating them in the same medium. These organisms grew in just the same way as the rat Trichomonas. Many times I tried to cultivate other kinds of trichomonad flagellates from the rat and trichomonads from the chicken and guinea-pig, but never obtained any positive results.

What condition of the culture medium is favorable for the growth of Trichomonas, alkaline or acid? Lynch first cultivated Trichomonas in neutral and acid bouillon, and Reuling was able to cultivate *Trichomonas vaginalis* in a culture medium which was acid by adding acetic acid solution, and transferred into new media every day. Hogue states, that "*Trichomonas* multiplies most rapidly in sodium chloride serum water with p_H 8. It lives longest in the same medium with p_H 7.2 to 7.4." Kofoid and Swezy say, that "*Pentatrichomonas* of man thrives best in neutral serum (p_H 7.4) and died out at 6.2 and 8.2 respectively." These workers studied the human Trichomonas, and moreover they state only the reaction of the culture medium before inoculation. They did

not note how it changed during cultivation. In order to determine how the medium changes during the growth of the organisms, I tested the reaction of the medium every day.

A small portion of cecal contents was inoculated into the culture medium. Before inoculation I tested the reaction and after that, at periods of 24 hours, taking out one drop of the medium by means of a capillary pipette on each occasion. In each series of experiments, five culture tubes were used and the same experiment was repeated several times. The results obtained in each series are nearly the same, hence the average results of three series only are presented in the following table.

Mass Culture

No. of Rats from Which Culture Was Made		Before Inoculation	24 Hours Later	48 Hours Later	72 Hours Later	96 Hours Later
2	Average number of organisms per field*	...	5.2	21.8	15.1	3.1
	p_H of the medium	7.2	8	8.4	8.6	...
3	Average number of organisms per field	...	8.3	32.8	28.7	5.2
	p_H of the medium	7.2	7.4	8	8.2	8.6
5	Average number of organisms per field	...	12.5	43.2	34.3	4.5
	p_H of the medium	7.2	7.6	8	8.3	8.6

* The number in the table indicates the average number of organisms in ten fields. One drop of the culture was placed on a slide by means of a capillary pipette and spread out under a cover glass (No. 18) and examined with a No. 10 ocular and 16 mm. objective.

In order to get a pure line culture, a very small amount of the cecal contents was diluted with culture medium, and very small drops of this were placed on pieces of cover glass, and examined quickly under the microscope. If a single organism was found in a drop, the piece of cover glass was dropped into a test tube containing culture medium. In this way, I inoculated ten test tubes, and got positive results in more than five of them. The reaction of the medium was tested in the same way as in the mass cultures. The results of this experiment are as follows:

Pure Line Culture

No. of Rats from Which Culture Was Made		Before Inoculation	24 Hours Later	48 Hours Later	72 Hours Later	96 Hours Later	110 Hours Later
5	Average number of organisms per field	...	...	...	3.2	7.4	1.2
	p_H of the medium	7.2	7.6	8	8.2	8.4	8.6
8	Average number of organisms per field	...	...	...	2.3	7.1	0.6
	p_H of the medium	7.2	8	8.2	8.4	8.6	...
13	Average number of organisms per field	...	...	...	2.6	7.8	2.1
	p_H of the medium	7.2	7.6	8	8.2	8.4	8.6

TRICHOMONADS FROM MAN AND OWL

Similar experiments were carried out with trichomonads from man and owl with nearly the same results as with the trichomonad from the rat. These experiments were carried out with only one strain in each case. Judging from the above results, p_H 8 to 8.2 is the most favorable for the growth of the rat Trichomonas and also seems to be for the human and owl trichomonads.

SUMMARY

1. Species of trichomonad flagellates from the rat, owl and man grow abundantly in a special culture medium.

2. This culture medium is advantageous in repressing bacterial growths.

3. The most favorable reaction of the culture medium for the rat Trichomonas is p_H 8 to 8.2.

4. The same reaction seems favorable for the Pentatrichomonas of man and for the owl Trichomonas.

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SOCIETY PROCEEDINGS

THE HELMINTHOLOGICAL SOCIETY OF WASHINGTON
EIGHTY-THIRD TO EIGHTY-NINTH MEETING

The eighty-third meeting was held January 17, 1925.

Dr. Stoll referred to recent work on determining the total egg output of persons harboring hookworms and stated that computations based on 24 to 48 hour fecal samples were likely to be faulty, since his own work has shown that 72 hour fecal samples were necessary in order to arrive at accurate conclusions regarding the total number of hookworms harbored.

Dr. Chapin exhibited a specimen of *Strongylus leptocephalus* Rud. from Bradypus sp. (believed to be *tridactylus*). After Rudolphi this species was studied by Leuckart in 1850 and by him made the type of the genus Leiuris Leuck. This genus was suppressed by Schneider in 1866 as a synonym of Filaria. In 1897 Stossich transferred the species to Spiroptera. In 1914, Neiva, Cunha and Travassos restudied the form and placed Leiuris as a synonym of Physocephalus. There is ample reason for excluding the species from this genus and Leiuris Leuck. should be revived as a valid genus of the subfamily Arduenninae of the family Spiruridae.

Miss Cram presented the following notes for Dr. Hall:

Ascaridia galli in the hen's egg.—The large roundworm of the chicken has been noted as having wandering habits comparable to those of *Ascaris lumbricoides*. It has been reported as present in hen's eggs and 5 such specimens are in the collection of the Bureau of Animal Industry. An additional report has just come from Mr. T. L. Simmons of Sheffield, Alabama. The worm measured 3¾ inches in length and on keeping it in an egg it gained an inch in length. This statement may be due to faulty observation or faulty memory. He also states: "At times it blows bubbles in an egg its full length;" but this is probably gas formed by decomposition.

Parasites of deer, Odocoileus sp.—Cysts from the lung of a deer killed at Canyonville, Douglas County, Oregon, were recently sent in by Dr. B. T. Simms of the Oregon Experiment Station with a tentative diagnosis of hydatid. This was confirmed by finding numerous scolices in the cysts. Dr. Bell of the Biological Survey states that the deer in western Oregon in general is *Odocoileus columbianus*, a new host for the hydatid, *Echinococcus granulosus*? An examination of the hooks indicates that the material belongs to this species and not to the recently described *E. cruzi*. The parasites reported from this deer at present are *E. granulosus, Fascioloides magna, Trichodectes tibialis, Linognathus ferrisi, Pulex irritans* and *Cervophthirius crassicornis*. The parasites reported from the deer in eastern Oregon, *O. hemionus*, are *Haemonchus contortus, Trichostrongylus extenuatus, Trichuris ovis, Taenia hydatigena, Trichodectes tibialis* and *Dermacentor albipictus*. These lists are compiled from Dr. Hassall's card catalogue. In addition may be added from *O. columbianus* the following parasites represented by specimens in the collection of the Bureau of Animal Industry: *Nematodirus filicollis, Chabertia ovina, Dictyocaulus filaria, Setaria labiato-papillosa, Thysanosoma actiniodes* and Moniezia sp. Another parasite collected from one of the two hosts and only identifiable at present as Odocoileus sp. is *Cysticercus* (?) *tarandi*, recently reported by Cram from the deer in Cow Creek Canyon, Oregon.

Miss Speer and Miss Orleman invited the attention of the Society to structures resembling trematode ova found in the bile and feces of a patient of Dr. Robert

Preston of Richmond, Va. These ova are single-walled and appear to be non-operculated. They vary in size from 126 to 138 μ in length by 68 to 76 μ in breadth. An attempt is being made to incubate them.

Dr. Stiles reported further ground water experiments at Fort Caswell, North Carolina. In January the bacteriological examinations of the 600B experiment showed positive *Bacillus coli* up to the 228 foot line or estimated diagonally, 232 ft. from nearest point of the trench; uranin had extended up to 414 ft. away from the trench. Thus as compared with last June the further extension of the bacteria was not established, but there was a distinct extension of the uranin. In the 500B experiment the pollution both by uranin and by *B. coli* had extended from 50 ft. last June to 70 ft. in January. The next examinations of the field will be made in May or June, 1925.

Mr. Christie presented the following note:

During the months of October and November, 1924, over 50% of the imported species of dung beetles, *Aphodius fimetarius,* collected in the vicinity of Falls Church, Va., were found to carry cysts of what is either *Rhabditis coarctata* Leuk. or a very closely related species. A considerable number of other dung beetles collected at the same time and in the same places as the infested *A. fimetarius* were examined but none found bearing cysts. The legs, particularly the outer margins of the tibia, are the most common points of attachment, but cysts may also occur on the margins of the head and thorax and on the elytra. What at first appears as a patch of soil or dung on the posterior part of the elytra may, on close examination, prove to be a cluster of a hundred or more cysts.

If these cysts are placed in a culture of fresh cow dung the larvae shortly begin to emerge and, after an interval of about 24 hours at room temperature, the culture swarms with adults, some of which have already begun giving birth to young. In from 24 to 36 hours after birth the larvae reach the encysting stage and if beetles are then added to the culture, cysts are formed immediately. Beetles placed in favorable cultures late in the afternoon are usually on the following morning heavily loaded with cysts. Not only is this true with *A. fimetarius* but cysts are formed as readily on *A. gramarius, A. inquinatus, Sphaeridium scarabaeoides* and *Cercyon* sp. Failure to find cysts on these and other dung beetles collected in the pastures is due, no doubt, to their habits which probably bring them less frequently in proximity to the rhabditid larvae when the latter are at an encysting age.

In order to test the selective tendencies of the larvae, there were placed in a culture several individuals of *Hoplocephala bicornis,* a beetle which lives under the bark of decaying stumps and logs and, in nature, would very rarely come into contact with dung or dung inhabitating nemas. Cysts were formed freely on the legs of these beetles. It would appear, therefore, that any available insect may become a carrier of cysts and the occasional finding of them on many different insects or even on the ectoparasites of insects is to be expected.

The formation of cysts has not been brought about on dead beetles or on any inanimate object.

These rhabdites probably feed on the micro-organisms of fresh dung and optimum conditions for their development exist for only a few days, a period about long enough for one generation. In order to continue life and perpetuate the species they must effect a transfer to fresh dung and protect themselves from desiccation during the transfer. This is effectively brought about when the larvae encyst on dung beetles which are continually flying from one lot of dung to another. Whether or not an encysted stage is a necessary part of every life cycle cannot be definitely stated but the author has been unable to rear a second generation of adults without first providing insects on which the larvae could encyst, even though fresh dung was added to the cultures.

Dr. Cobb also presented notes on (a) the significance of birefringents in living cells, (b) the cleaning of nema-infested clover seeds, and (c) nemas injurious to fruits and vegetables.

The eighty-fourth meeting was held February 21, 1925. Dr. R. Hoeppli was elected a member of the society.

Dr. Ewing exhibited the skin of a Panama howler monkey (*Alouatta palliata inconsonans*) infested with Cuterebra larvae.

Dr. Stiles presented the following notes:

1. Karyamoeba Kofoid and Sweezy is a stillborn homonym. Dr. Stiles stated that the authors will change the name to Karyamoebina.

2. A new case of *Dioctophyme renale* free in the abdominal cavity of a dog was discovered in the Johns Hopkins Hospital.

3. The parasite eggs from the bile of a patient that had been exhibited at a previous meeting by Misses Speer and Orleman may be unfertilized eggs of *Ascaris lumbricoides,* this suggestion having been made by Dr. Choisser of the Naval Medical School.

Dr. Hoeppli presented the following note:

An examination of the cellular structure of the anterior end of different ascarids, in general confirmed the statements published by Goldschmidt in 1903 with reference to *Ascaris lumbricoides.* The anterior end contains a constant number of large cells that always show the same arrangement. The "Arcadenzellen" group at the beginning of the esophagus has a different arrangement from that described by Goldschmidt. I found six new small sense organs at the inner surface of the lips and was able to extend Goldschmidt's description of the amphids. A comparative study of eight different species of ascarids showed the same cell arrangement in the anterior end. Studies which are as yet unfinished show that the large intestinal roundworm of chickens (Ascaridia) shows the same arrangement and number of cells in the lips as those shown by various species of Ascaris that have been examined.

Dr. Steiner spoke on nemas parasitic in peanut plants in South Africa and some East and West African colonies. Ten different species were found in the tissue of affected plants. Some of these are new. The diseased plants showed swellings on the stems and a shortened condition, resulting in a "rosette" appearance. The disease therefore is called "rosette disease." The determination of the primary cause is somewhat difficult because of the presence of various species, some of which were rather abundant. Because of their number and presence in all samples, *Tylenchus cylindricaudatus* Cobb mss and *Cephalobus elongatus* are thought either singly or together to be the initiators of the trouble. The other forms are conceived as aggravating the conditions of the disease and aiding in the final breaking down of the plant attacked. From a morphological point of view all the forms showed amphids, the species of Cephalobus and Acrobeles had phasmids and in a number of them deirids also were observed. The latter are apparently homologous with the so-called cervical papillae well known in many parasitic nemas.

Dr. Cort presented the following note:

Epidemiology of Hookworm Disease in China.—Hookworm disease in China is an occupational disease almost entirely limited to the farming class and its spread seems to be due almost exclusively to the use of the human wastes in fertilizing the soil. In the cooler dry regions to the north of the Yangste River this disease is kept under control by climatic conditions unfavorable to its spread, and nowhere in this region has it been reported to be a public health problem. Over a considerable part of the area south of the Yangste River the climatic conditions appear to be favorable so that its distribution and importance in any regions depends on whether the methods of application of the night soil used as fertilizer is favorable to the completion of the life cycle of the parasite. Reports from this region show a widely scattered and rather general hookworm infestation but in many places few if any clinical cases. Apparently only a very favorable combination of circumstances produce conditions which make the hookworm infestation so heavy that the disease becomes an important public health problem. Such conditions are found in the silk producing areas of southern

Kiangsu and northern Chekiang, in restricted localities in Hupeh and Hunan provinces, in Szechwan province and in Kwangtung. Even in these places the reports show that the distribution is spotted and closely situated places may have very different conditions.

The peculiar distribution of hookworm disease in South China is due to the fact that it is spread by the use of the human wastes as fertilizer rather than by general soil pollution. The methods used in the fertilization of such crops as rice and cotton were found in certain regions to be unfavorable to the development of hookworm disease. On the other hand the methods of using the night soil in mulberry groves in southern Kiangsu province was found to produce very severe endemic centers. It can be inferred then that the hookworm situation in any given area of South China will depend both on the type of crops cultivated and the methods of application of the night soil. The development of control measures for hookworm disease in any region in China will have to depend on a definite knowledge of the methods of night soil fertilization which make its spread possible. On account of the low economic level of the farmers they should involve as little expense as possible. It is probable that in various local situations only slight modifications of existing habits would be necessary to break the hookworm cycle. A very promising line of attack is to increase the period of storage of night soil before its use as fertilizer.

The eighty-fifth meeting was held March 21, 1925. Dr. T. B. Magath was elected an American corresponding member.

Dr. Hoeppli exhibited a specimen said to have been passed in the urine of a person in Cuba. The specimen appeared to be a turbellarian.

Dr. Cobb exhibited specimens of parasites from a salamander collected by Dr. Blanchard of the University of Michigan. He discussed the question of the synonomy and specific identity of species of Nematoxys.

Dr. Stiles reported on a pseudoparasite one half inch long which was determined as a flagellate by his correspondent but which proved to be a vegetable cell.

Mr. Sandground outlined his work on the life history of Strongyloides.

Dr. Steiner exhibited drawings of a remarkable new Mermithid for which the name *Tetramermis vivipara* is proposed. Tetramermis has four head papillae, but no mouth papillae, a ventrally shifted mouth opening, large amphids at some distance behind the head papillae, no cross fibers in the cuticula, a short, non-tubular vagina, and two spicula. The present species is especially remarkable because it is the first viviparous Mermithid known. Furthermore it shows a matricid viviparity, e. g., the larvae remain in the body of the mother and in time fill it out completely. The speaker is inclined to consider this as a kind of adaptation to the special desert conditions of the region where the specimens were collected. They were found by Mr. Gerald Thorne of Salt Lake City, in ephemeral water in Dog Valley Spring, Vernon Creek, Utah. All the larvae contained in the body of the mother were at the same stage of development and had already entered the body cavity of the mother. No younger stages nor eggs could be seen. The cuticula of the mother serves apparently as a protecting cyst during unsuitable seasons (dryness, etc.) and may release the young larvae under favorable conditions.

The eighty-sixth meeting was the annual dinner of the society held April 25, 1925. Dr. Henry B. Ward and Professor Frank G. Haughwout were guests of the Society.

The eighty-seventh meeting was held May 16, 1925. The following officers were elected for the ensuing year: president, Dr. G. Steiner; secretary, Dr. B. Schwartz; corresponding secretary, Miss E. B. Cram.

Dr. Cobb gave a detailed description of the parasite from a salamander, specimens of which he had exhibited to the society at a previous meeting.

Dr. Ransom discussed the work that is being carried on by the Bureau of Animal Industry and by several states independently bearing on the control of

roundworms (Ascaris) in swine. He explained the system of swine sanitation that was developed by the Bureau of Animal Industry and exhibited posters that are being used by certain states for the education of farmers concerning the question of the prevention of ascariasis. Dr. Ransom also exhibited a small poster containing a graphic outline of the life history of the stomach worm (*Haemonchus contortus*) and the method of dosing sheep harboring these worms.

Mr. Christie presented the following note:

At a meeting of this society on January 19, 1924, the writer reviewed briefly the embryology of *Agamermis decaudata* and in this connection pointed out that the eggs averaged about 166 μ in diameter except in the case of those deposited by females 12 cm. or less in length in which case the diameter of the egg averaged only about 122 μ. When this fact was determined, it was suspected that the nemas depositing ova of this small size constituted a distinct species but a most careful examination of the adults by both Dr. Steiner and the writer failed to substantiate these suspicions. So closely did such adults resemble typical *A. decaudata* adults that one is forced to regard them all as the same species. Since that time, however, preparasitic larvae have been reared from these small ova. Larvae so obtained are less than half as large as those of *A. decaudata* and differ from them in several anatomical features. In addition there is evidence which indicates that they have specific host affiliations. In view of these and other facts it is difficult to avoid the conclusion that the Mermithids, depositing the small ova referred to above, constitute a valid species. Details regarding specific differences which separate them from *A. decaudata* will, however, be published later when the species in question is named and described.

While studying the immature stages of various Mermithidae the writer has been impressed by the apparent value of the preparasitic larva as an aid in determination of species. The Mermithid preparasitic larva is, in a sense, a mature individual; not sexually mature, it is true, but an organism which has completed one phase of its complicated life cycle. Its clear cut highly organized condition, together with its transparency and convenient size, make it a most favorable object for microscopic study. The relative size of the cephalic portion and of the trophosome; the structure of the node when present; the number, arrangement and structure of the elements of the trophosome are all outstanding characteristics which, in the light of present knowledge, appear to be of pronounced taxonomic value. Once within their host, the larvae increase enormously in size, become very opaque and undergo a sort of convergent ontogenetic evolution so that at the time of emergence different species may resemble each other very closely. It is often only by the most careful and painstaking study that they may be accurately differentiated. Further difficulty and confusion results from the fact that adult individuals within a species show a considerable range of variation in what are at present regarded as fundamental characters. It is not the contention of the writer that the taxonomy of this group should be based on larval characters. Even if philosophical, this would be at least an unworkable system. Nevertheless it does seem probable that the preparasitic larvae will prove highly valuable when adult characters are found difficult and confusing.

Dr. Ackert forwarded the following note by Dr. Minna E. Jewell:

Cysticercus pisiformis in the lungs and pericardium and beneath the costal pleura of a rabbit.—The examination of a Mearns cottontail (*Sylvilagus floridanus Mearnsii*) showed an unusually heavy infestation with *Cysticercus pisiformis* Zeder in various parts of the body including the lungs and pericardium. The rabbit was shot November 28, 1923, on a farm near the southeast border of Marshall County, Kansas. No observations were made on the living rabbit, but its general appearance was normal, the hair in good condition and the body in good flesh. Upon opening the abdominal cavity it was found to be literally packed with cysticerci, over 100 c c. of which were dipped from the body without dissection. Aside from the large numbers free in the body cavity the mesenteries and liver were heavily infested, and specimens were removed from beneath the peritoneum and between the muscles of the back, especially along

the median dorsal line. However, no cysticerci were found in the muscles, kidneys or urinary bladder. An examination of the thoracic cavity showed a heavy infestation in the region of the lungs. Of these cysticerci, many were in the lungs, some in the pleural cavity, others outside the costal pleura and a few were in the pericardium. No specimens were found in the tissues of the heart itself. Examinations of the muscles of the legs, and of the brain and meninges gave negative results. One thousand fifteen cysticerci were taken from the rabbit besides several which were not dissected out of the lungs and liver. This case is regarded as worthy of mention, not only because of the extent of the infestation, but also because it appears to be the first report of *Cysticercus pisiformis* from the lungs and pericardium and from beneath the costal pleura of the rabbit.

The eighty-eighth meeting was held on September 19, 1925. Dr. Hall was nominated resident vice-president of the Washington Academy of Sciences to represent the Helminthological Society. The following statements concerning the deaths of Dr. Samuel Taylor Darling and Dr. Brayton Howard Ransom were approved for publication in the proceedings.

The Helminthological Society of Washington has lost by the death of Dr. Samuel Taylor Darling one of its most distinguished members. Dr. Darling was elected a corresponding member of the Society in January, 1913, while he was in Panama and was an active member during the years 1920 to 1922 while he was in Baltimore. Dr. Darling's career of investigation began in 1903 when he was appointed intern and physician in the Ancon Hospital in Panama. In 1906 he was made Chief of the Laboratories of the Isthmian Canal Commission. During the ten years he remained in this position his principal interest was centered on animal parasites. His investigations covered a wide field, his published results including as subjects especially trypanosomiasis, endamoebiasis, and piroplasmosis. The succeeding ten years of Dr. Darling's life were spent as a member of the staff of the International Health Board of the Rockefeller Foundation. He accompanied General Gorgas on a sanitary mission to South Africa in 1913-1914; spent two years in Malaya, Java and Fiji as head of a medical commission for the study of hookworm disease and malaria; and established the Laboratories of Hygiene in the Medical School at São Paulo, Brazil. During the last years of his life he was in charge of an experimental station for the study of malaria at Leesburg, Georgia.

Dr. Darling is best known as a student of hookworm disease and malaria. He was particularly interested in the mass treatment of hookworm disease and in the geographical and ethnological distribution of hookworms. His malaria work has been of very great value from both the scientific and practical standpoint. He did his bit to make the digging of the Panama Canal possible, and was always an enthusiastic student of every phase of the malaria problem. His wide experience made him one of the great international authorities on this subject and he met his death by accident while traveling as a member of the League of Nations' Malaria Commission in Syria.

Dr. Darling was an inspiration to everyone who was so fortunate as to be associated with him. His enthusiasm for his work and singleness of purpose were characteristics that impressed all who knew him. Besides this he was a charming gentleman and devoted friend. The Society deeply feels his loss.

The Helminthological Society of Washington deeply deplores the untimely death of Dr. Brayton Howard Ransom, one of its founders and one of its most distinguished members. Dr. Ransom was an active member of the Society from the time of its organization in 1910, its president from 1919 to 1920, and its representative in the Washington Academy of Sciences as resident vice-president of the Academy since 1923. His loyalty and active interest have been important factors in the development and growth of the Society.

Dr. Ransom's scientific activities covered a period of about 25 years of uninterrupted research resulting in many important and far-reaching discoveries in the field of parasitology. His individual contributions to knowledge, and those made in collaboration with his associates, cover a wide range of topics, including

among other things the elucidation of the life histories of economically important parasites, notably those of *Haemonchus contortus, Taenia ovis,* Habronema, Gongylonema, Syngamus and Ascaris. His contributions to our knowledge of prophylaxis against parasitic diseases, notably trichinosis and ascariasis, rank among the leading practical achievements of the Bureau of Animal Industry. His monographic studies of cestodes of birds, nematodes of ruminants, as well as numerous other contributions to systematic helminthology, have served as models for similar investigations. These and his other accomplishments in the field of applied zoology raised Dr. Ransom to the rank of an outstanding figure in parasitology. In his death the world has lost a distinguished scientist and the United States has lost one of her most eminent parasitologists.

Dr. Ransom won the admiration of his colleagues not alone because of his scientific achievements but also because of his charming personality, his gentleness and his courteous consideration of those with whom he came in contact. In mourning his death, the Society takes pride in his achievements and feels a deep appreciation for having been enriched for many years by close association with him.

The eighty-ninth meeting was held on October 17, 1925.

Dr. G. F. White reported on larva migrans in man in Florida and exhibited sections of the skin containing a nematode larva.

Dr. R. W. Hegner reported on protozoa that live in pitcher plants. These studies were undertaken with a view to investigating the behavior of protozoa that live in a medium known to contain digestive enzymes in order to throw light on the problem of intestinal parasitism among the protozoa. An examination of pitcher plants at the Biological Station of Salisbury Cove, Maine, showed that they harbored rhizopods, ciliates and flagellates. No definite decision was reached as to whether the species found were free living forms adapted to a peculiar environment. Pitcher plants were inoculated in the laboratory and in the field with Paramoecium and these organisms were also kept under observation in the laboratory in the liquid of pitcher plants on hollow ground slides. They thrived well in this medium, multiplying in some cases.

Upon Dr. Stiles' request Dr. Hegner reported on two cases of flagellate diarrhoea due to Trichomonas that were apparently cured by a largely carnivorous diet. He also reported two cases of giardiasis that were partially cured by such diet. Dr. Stiles added another clinical case of giardiasis of long standing that was cured by a largely carnivorous diet.

Dr. R. J. C. Hoeppli presented the following note:

Numerous hot springs and geysers in different parts of Yellowstone Park were examined for free-living nematodes. There were found altogether seven different species, among them a Dorylaimus secured several years ago by Dr. N. A. Cobb in material from Yellowstone Park. This species occurs in water over 40 ° C. as well as in water of normal temperature. Besides Dorylaimus there were in the material a new species of Diplogaster and Plectus, a species nearly related to Microlaimus which must be placed in a new subgenus, *Mononchus brachyuris, Mononchus macrostoma* and *Aphelenchus parietinus.* These forms occur in the overflow of hot springs in water which had cooled off to atmospheric temperature. The new species do not show any morphological characters which can be regarded as caused by the exceptional surroundings, such as the temperature or the high mineral content of the water.

Dr. C. W. Stiles stated that in preparing the fourth number of the Host Catalogue (Key-Catalogue of the animal parasites reported for Primates), considerable difficulty has developed because of the lack of uniformity in the nomenclature of the hosts. This confusion is due primarily to two factors, namely, many authors have not followed the principle of genotypes and some authors have not complied with the Rules, especially as respects the names of subgenera. For instance, two of the most important works of reference, Troues-

sart's (1897c) Cataloguds Mammalium, and Elliot's (1912, 1913) Review of the Primates, have departed materially from recognized rules of nomenclature. This fact has a direct bearing on the records in parasitology and to reduce confusion Dr. Stiles advised that parasitologists cite, when possible, both the technical and the vernacular names of hosts in their records. For instance, prominent specialists in mammalogy use the generic name Simia for three distinct genera, i. e., the chimpanzee, the orang-outang, and the Barbary ape, while the specific name *Simia satyrus* is confined by some authors to the chimpanzee and by others to the orang-outang. As various primates are coming more and more into use in experimental work, the point under consideration is increasing in importance for the parasitologist. He sounded a note of warning especially in regard to adopting the generic and the subgeneric names for hosts as used in Elliot's extensive monograph, unless parasitologists specifically state that they are following that work. Until the nomenclature of the Primates becomes more settled, he suggests that the names adopted by Lydekker (1911) in the Encyclopedia Britannica, though not free from objection in all respects, have the advantage of being quite generally accessible. For the names of North American mammals, he advised that all parasitologists adopt Miller's (1924a) List in Bull. 128, U. S. National Museum.

Dr. Stiles stated that recently he had found bibliographic references in parasitology to the *Bulletin of the International Health Board* which could not be verified in the Washington libraries. Upon obtaining a copy of one number of this document he had come to the conclusion that this is not "publication" in the sense of the zoological profession and therefore that it is not subject to citation. To confirm this interpretation he communicated with the Rockefeller Foundation and was informed that this same view is held by that office; in fact, "beginning with the number for July, 1923," this document bears the statement: "Published quarterly by the International Health Board of the Rockeller Foundation, 61 Broadway, New York City, for the personal information of the Board and its staff. Since the *Bulletin* is not designed for general distribution it should not be quoted or referred to in other publications." It will be well for parasitologists to give consideration to this point so as to preclude confusion in parasitology similar to that which has developed in other fields, as for instance in the Lepidoptera because of citation of Hübner's (1806) Tentamen.

Dr. Stiles reported that the first number of the Host Catalogue has been issued as Stiles and Hassall (1925a) Key-Catalogue of the Protozoa Reported for Man, Bull. 140, Hyg. Lab. The second number is now in press as Key-Catalogue of the Worms Reported for Man, Bull. 142, Hyg. Lab. The revised mailing list is supposed to contain (among others) the names of all professional parasitologists of the world and also the names of all members of the American Society of Zoologists. If the name of any person in these two groups has been inadvertently omitted (as would be shown by failure to receive these bulletins) Dr. Stiles requests he be notified as promptly as possible.

Dr. Benjamin Schwartz presented the following notes:

The chicken as a host for *Metroliasthes lucida.*—This cestode is of common occurrence in the intestine of turkey. It was reported from a chicken by Ransom in 1905 with considerable reservation, the report being based on a specimen in the Helminthological Collections of the Bureau of Animal Industry collected in 1893 and determined by Ransom in 1904. Ransom evidently doubted the validity of the host record since he stated in 1905 that the occurrence of *Metroliasthes lucida* in chickens is doubtful. Recently Southwell (1921) reported the occurrence of this species in chickens in India. Additional cases of the occurrence of this species in chickens were found in a collection of parasites from South Africa forwarded to the Zoological Division of the Bureau of Animal Industry for determination. Two lots of cestode material from chickens were identified as *Metroliasthes lucida,* one lot containing a few specimens and the other lot containing numerous specimens. Other hosts for this cestode are *Numida ptilorhyncha, Numida* sp. and *Coturnix coturnix coturnix.*

Geographical distribution of *Oesophagostomum longicaudum*.—In a recent paper Goodey (1925) has described under this name a new species of nodular worm from swine in New Guinea. An examination of specimens of Oesophagostomum from swine in the Helminthological Collections of the U. S. National Museum showed that the new species has been collected in the United States, in the Philippine Islands, in Tonkin (Indo-Chino), in the Fiji Islands and in China. The species is probably of world wide distribution.

A new case of *Dioctophyme renale* in the District of Columbia.—Recently Dr. Robert Formad of the Pathological Division of the Bureau of Animal Industry collected two specimens of this species from the abdominal cavity of a dog in the District of Columbia. The dog in question was suspected of being infected with rabies, but examination for the presence of negri bodies yielded negative results.

Additional records of parasites from the Philippines.—The following parasites hereofore unrecorded from the Philippine Islands have been identified, the specimens having been collected in and near Manila. *Dipylidium sexcoronatum*, *D. oerleyi*, *Physaloptera praeputialis* and *Dirofilaria immitis* from dogs; *Davainea tetragona* from chickens; *Moniliformis moniliformis* from rats, *Aprocta rotundata* from *Centropus viridis* and *Paragordius varius*, free-living. *Aprocta rotundata* was collected by Mr. Banks, formerly of the Bureau of Science at Manila, and forwarded to the Bureau of Animal Industry with the information that the specimens were found in the intestines. This location is rather unusual for a filarid, although it may be noted that Shipley (1903) reports this parasite from *Centropus sinensis* from the Malay Peninsula as probably occurring in the alimentary canal.

Dr. E. A. Chapin presented the following notes:

Ancylostoma pluridentatum (Aless.), heretofore not recorded from the United States, was collected from the small intestine of *Felis tigrina*, Oct. 13, 1925. The host animal came to the Zoological Division from the National Zoological Park, where it had been held in captivity since July 13, 1925.

A turkey (*Meleagris gallopavo*) received from Churchton, Md., Oct. 6, 1925, was heavily infested with mites belonging to the species *Freyana* (*Microspalax*) *chaneyi* Trt. and Mégn. Many thousands of the mites were present, the grooves of the remiges being in some cases completely filled with living mites and shed skins. This parasite appears to be wide spread in its distribution but not generally common.

Dr. S. L. Hung presented a note on his attempts to establish human hookworms (probably *Ancylostoma duodenale*) in white rats. He concludes that human hookworms fail to establish themselves in rats up to five days after infection but can be found during this period free in the intestine and in the feces. Those larvae recovered three and five days after infection show definite increase in length, evidently indicating some ability to feed and grow upon rat tissue ingested during migration. No marked skin reactions at the site of infection could be detected.

Dr. Hung exhibited slides of stained lung tissue of *Sus scrofa domestica* showing heavy invasion by eosinophile cells. This eosinophilia was associated with a pronounced infestation of the host animal by *Metastrongylus* sp.

Dr. Eloise B. Cram presented the following note:

New records of economically important nematodes in birds. In bird viscera sent to the Zoological Division of the Bureau of Animal Industry recently for information as to possible cause of death, I have found the following nematodes:

Amidostomum anseris in the gizzards of geese (*Anser cinereus domesticus*) from a flock at Brewerton, New York. These nematodes were present in enormous numbers and were the probable cause of the deaths of a large number of the birds. In 1894 Stiles and Hassall reported this species without query as *Strongylus nodularis*, which is a synonym of *Amidostomum anseris*, from *Somateria dresseri* in Maryland, but on a label in the bottle containing the

specimens this determination was questioned at the time it was made and upon examination of the specimens, I find that they do not fit the description of this species. There appear to have been no other reports of this nematode in this country up to the present time.

Thominx strumosa (which appears to be synonymous with *Trichosoma annulatum* Molin, 1858, and should therefore be *Thominx annulata*) from a turkey (*Meleagris gallopavo*) from Churchton, Maryland, the crop and the undilated esophagus being very heavily infested with the nematodes. This appears to be the first finding of this parasite in this country and the first finding in this host, the usual host being the chicken and the pheasant.

Echinuria uncinata from tumors at the junction of proventriculus and gizzard of two green-winged teals (*Nettion carolinense*) from Idaho. This parasite has not been previously reported from this country or from this host. In Europe it occurs in domestic ducks and geese, often proving fatal to them because of the occlusion of the lumen of the proventriculus by the tumors, and consequent obstruction to the passage of food. The presence of the nematode in wild ducks in this country indicates a possibility of its spread to domestic birds in the future.

Trichostrongylus pergracilis from the intestine of quail (*Colinus virginianus*) of Georgia. This nematode has apparently not been reported from this host or from this country until the present time, but I find in the collection of the Zoological Division specimens collected and determined as this species, but with query, by Dr. E. C. Stevenson, from this host in Alabama in 1907. Upon examination of these earlier specimens, I find no reason for not classing them as this species. In England grave pathological conditions in the red grouse (*Lagopus scoticus*) have been attributed to this nematode.

Dr. W. W. Cort presented the following note:

The Development of *Agamodistomum marcianae* (LaRue)—In 1917 LaRue described a larval trematode *Agamodistomum marcianae* from a snake of the genus Thamnophis and in the following year I found the same form in tadpoles at Douglas Lake, Michigan, worked out its excretory system completely and showed its relationship to the group of forked-tailed cercariae with pharynx. Last summer I discovered the cercaria which belongs to this form in one out of 220 specimens of *Planorbis trivolvis* Say and in one out of 234 specimens of *Planorbis companulatus smithi* Baker. In this cercaria the excretory system has five pairs of flame cells on each side in the body and one pair on each side in the tail, making therefore, a flame cell for each division of the accessory collecting tubes of the agamodistome stage, i. e., the number of flame cells in the body of the cercaria must be multiplied by six to produce the flame cell pattern of *A. marcianae*.

I placed a large number of the cercariae in a small dish with several tadpoles and they penetrated so actively that the tadpoles soon died. On July 3, I exposed ten tadpoles to small numbers of the cercariae each day for ten days. Theoretically these tadpoles could not be previously infected with any trematode stages since the water of Vincent Lake from which they came is so acid that no snails whatever exist in it. The examination of control tadpoles showed no parasitic infection. Later examinations of these tadpoles showed very large numbers of *A. marcianae*. The further development of *A. marcianae*, however, still remains a mystery. Recent work has shown in a number of cases that forked-tailed cercariae with pharynx develop into holostome larvae (tetracotyle or diplostomulum) and are the cercarial stages of worms belonging to the family Strigeidae. *A. marcianae* is either a stage in a more complicated life cycle than any so far recorded for this group, or represents an aberrant development in an abnormal host.

Dr. N. R. Stoll referred to Hall's note at the meeting in March, 1923, on Intrauterine Infestation of Dogs with Hookworms, which stated "as hookworm eggs appear in the feces in four to five weeks in experimental infestations, these findings point definitely to prenatal infection." Some published data by F. K. Payne Am. Jour. Hyg., 3: 584) indicate a probably different interpretation.

Three dogs experimentally infected showed ova in the feces within fourteen days. Dr. Stoll collaborated in this work and the probability is strong to him that fourteen days is not the minimum figure for the necessary interval between larval infection and ova in the feces for *A. caninum*. Hookworm eggs in the feces of pups one to two weeks old are thus inconclusive evidence of intra-uterine infestation; as are worm eggs present in the feces (of pups) . . . 13, 14 and 15 days old given by Adler and Clark (1922, Ann. Trop. Med. Hyg., 16: 353).

Dr. Stoll also referred to additional evidence supporting the conclusion (Stoll and Tseng: Am. Jour. Hyg., 5: 536) that egg counts in hookworm infestations measure the severity of the disease. Recent work by Warren and Carr in Mexico, Smillie and Augustine in Alabama, earlier work by Payne, Cort and Riley in Porto Rico, as well as a second group in China, all show a significant coefficient of correlation between egg counts and anemia (hemoglobin readings). This indicates that severity of hookworm infestations is directly measurable by egg counts as well as by worm counts; it gives indirect evidence also on the accuracy of the dilution egg counting technique.

BENJAMIN SCHWARTZ, *Secretary.*

AMERICAN SOCIETY OF PARASITOLOGISTS

Plans for the Kansas City meeting of the American Society of Parasitologists are well under way. Every effort is being made to develop a program of the greatest possible interest for the members who can be present. The program is centered around a joint Symposium with Section N (Medical Sciences) on The Medical Aspects of Parasitology in the United States which will be given on Wednesday afternoon, December 30th, and the address of the retiring president, Doctor Henry B. Ward, who will discuss the present status of and opportunities for parasitological work in the United States. The open sessions for presentation of papers by the members promise to be of unusual interest. Papers will be presented on practically every phase of parasitology and many of the older men as well as the younger workers are appearing on the program. The membership of the society has gone considerably beyond the 200 mark and is now representative of all phases of American Parasitology. A number of foreign parasitologists have become active members and it is expected that this number will be considerably increased.

LONDON SCHOOL OF HYGIENE AND TROPICAL MEDICINE

DEAR SIR:

I have read with interest the paper by Weidman on Hepaticoliasis in the *Journal of Parasitology* for September. I think, however, that it is necessary to utter a word of caution as regards the suggestion that infection with *Hepaticola hepatica* may be used as a means of exterminating noisome animals. In this connection I would draw the author's attention to a paper by Dive and Lefrenais, with an accompanying note by MacArthur, which appeared in the *Journal of the Royal Army Medical Corps* for July, 1924. It deals with a case of deposition of the eggs of *Hepaticola hepatica* in the human liver, infection having been acquired in India. It is the first account of such an invasion in man, but I think it should make one very chary of utilizing *Hepaticola hepatica* as a means of controlling vermin.

I am yours faithfully,

ANDREW BALFOUR, *Director.*

THE EDITOR, JOURNAL OF PARASITOLOGY.

ANNOUNCEMENT

The Editorial Board of the Journal with this issue records the addition to its membership of Dr. Maurice C. Hall of the Bureau of Animal Industry and Dr. W. G. Smillie of the International Health Board.

NEW HUMAN PARASITES

Leeuwenhoekia australiensis Hirst 1925.—This mite attacks people working in gardens at Sydney, New South Wales. It causes great irritation and is said to burrow into the skin. The attacks occur annually, the mites being present from about October until April. They seem to prefer moist surfaces, such as the axilla under waist bands and corsets, round the eyelids, etc. The adult forms of the mite are not known. This is not only the first record of a mite belonging to the genus Leeuwenhoekia attacking human beings, but is also the first record of the occurrence of this genus in Australia. (Trans. Royal Soc. Trop. Med. Hyg., 19: 150-152.)

Spirochaeta hussi-werneri Jakinov 1925.—A young man from Kiew suffered five febrile attacks and in the first attack spirochetes were found in the blood differing from *S. recurrentis.* The author favors the view that these organisms were the causative agents of febris volhynica. (Rev. Microbiol. Epidemiol. Saratov, 3: 3. [Abstract in Trop. Dis. Bull., 22: 717.])

Tarsonemus affinis Kishida and Harada 1925.—This tick occurred in the urine of an adult, 45 years old, and probably infested the pubic hair, dropping off accidentally in the course of urination. Although the tick is closely related to *Tarsonemus latissimus,* it is considered to represent a new species. (Chugai Iji Shimpo, 44: 14 [Japanese]; abstracted in Jap. Med. World, 5: 5, no. 9.)

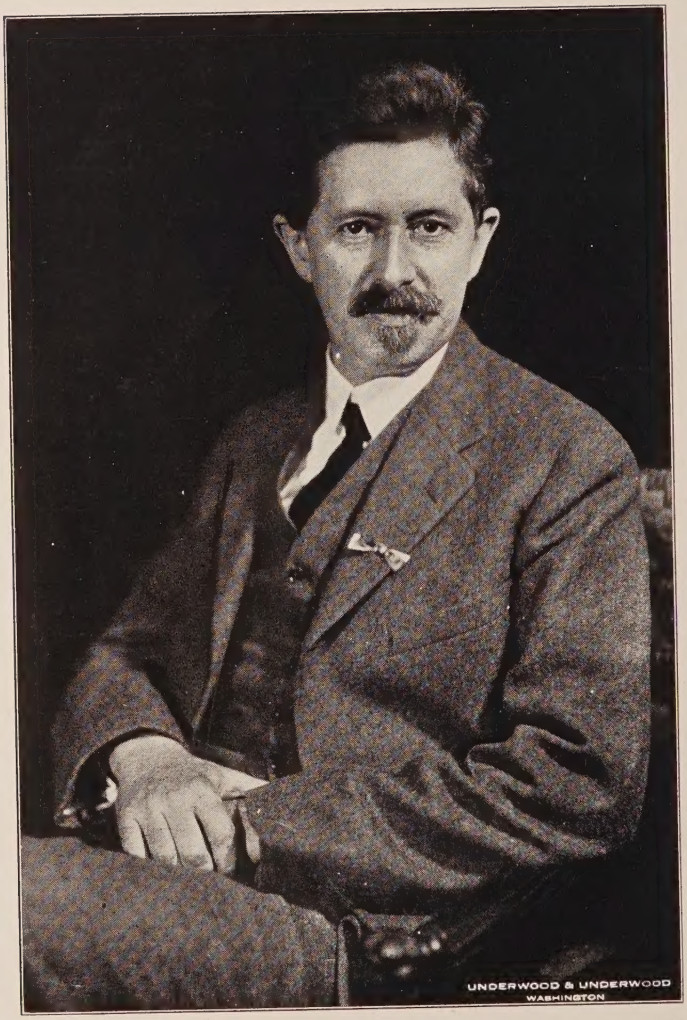
NOTES

Monodontus trigonocephalus (also known as *Bunostomum trigonocephalum),* which has not hitherto been reported from the Philippines, was found in a young ram that died at Zamboanga. In company with it were Trichostrongyloides, Trichuris, and Oesophagostoma. The numerous specimens of Monodontus simulated precisely in posture, color and external appearance *Necator americanus.* The male bursa showed distinctive characteristics for the positive determination of the species.

C. Manalang.

It is with profound regret that the Journal records here the death on Sept. 17, 1925, of Dr. Brayton H. Ransom, Chief of the Division of Zoology in the Bureau of Animal Industry, Washington, D. C. Of his services to science in his chosen field, which were truly outstanding, adequate mention will be made in a later number. But even this brief notice cannot be closed without some record of his services to the Journal. He was one of the first to approve of its establishment and to aid in the formulation of its plans. From the start he has served on its Editorial Board and in a quiet but effective fashion has ever manifested his interest in its welfare. The series of brief notes on New Human Parasites has been prepared and kept up to date by his efforts. In the criticism of manuscripts offered for publication and in many other details that make the management of such an enterprise a heavy load, he has consistently carried more than his share of the burden. In his death the Journal loses one of its most devoted and able supporters.

On Aug. 24, 1925, died Professor Franz Doflein of the University of Breslau, a distinguished investigator and writer in the field of parasitology. His major contributions dealt with the parasitic protozoa and form an important part of our knowledge in that field.



SAMUEL TAYLOR DARLING

1872—1925